SPE JOURNAL

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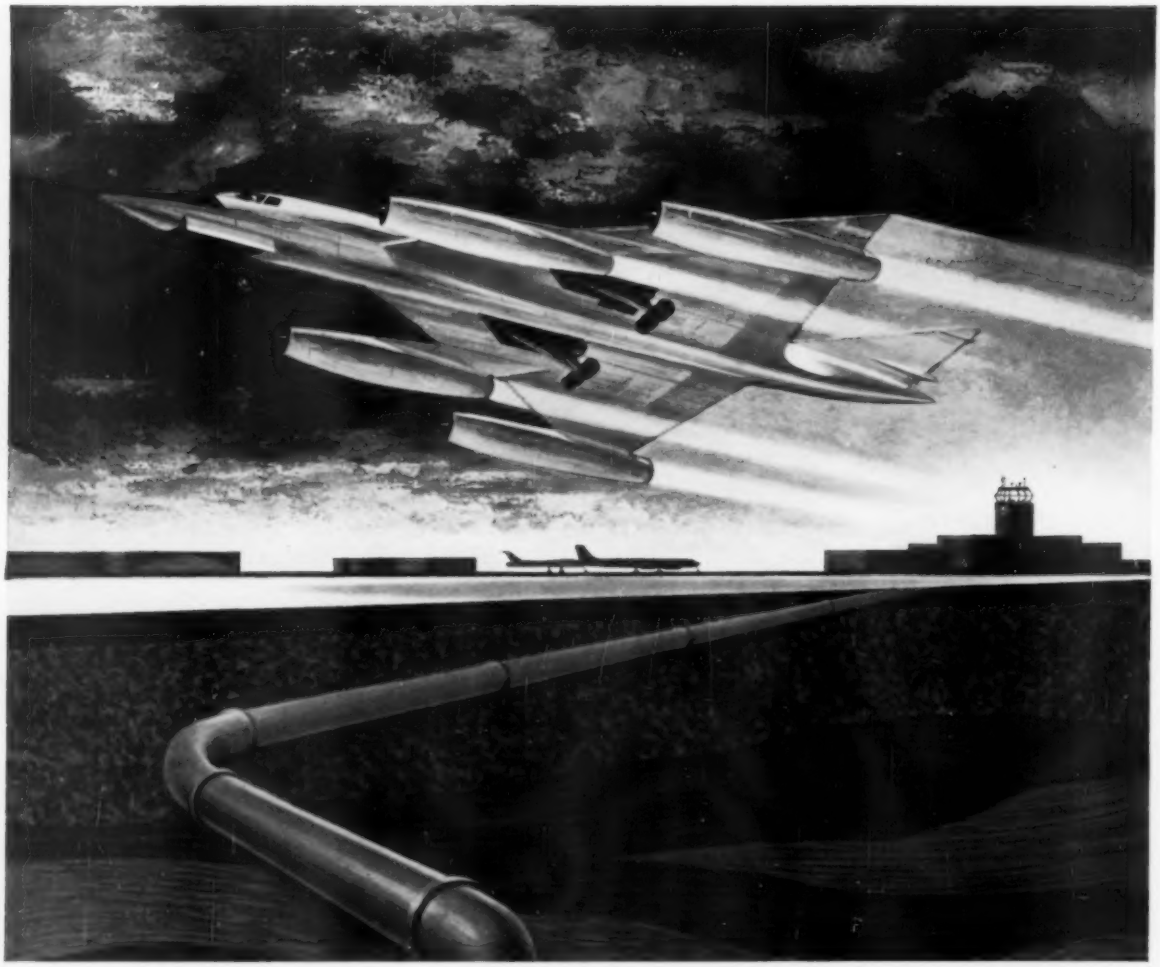

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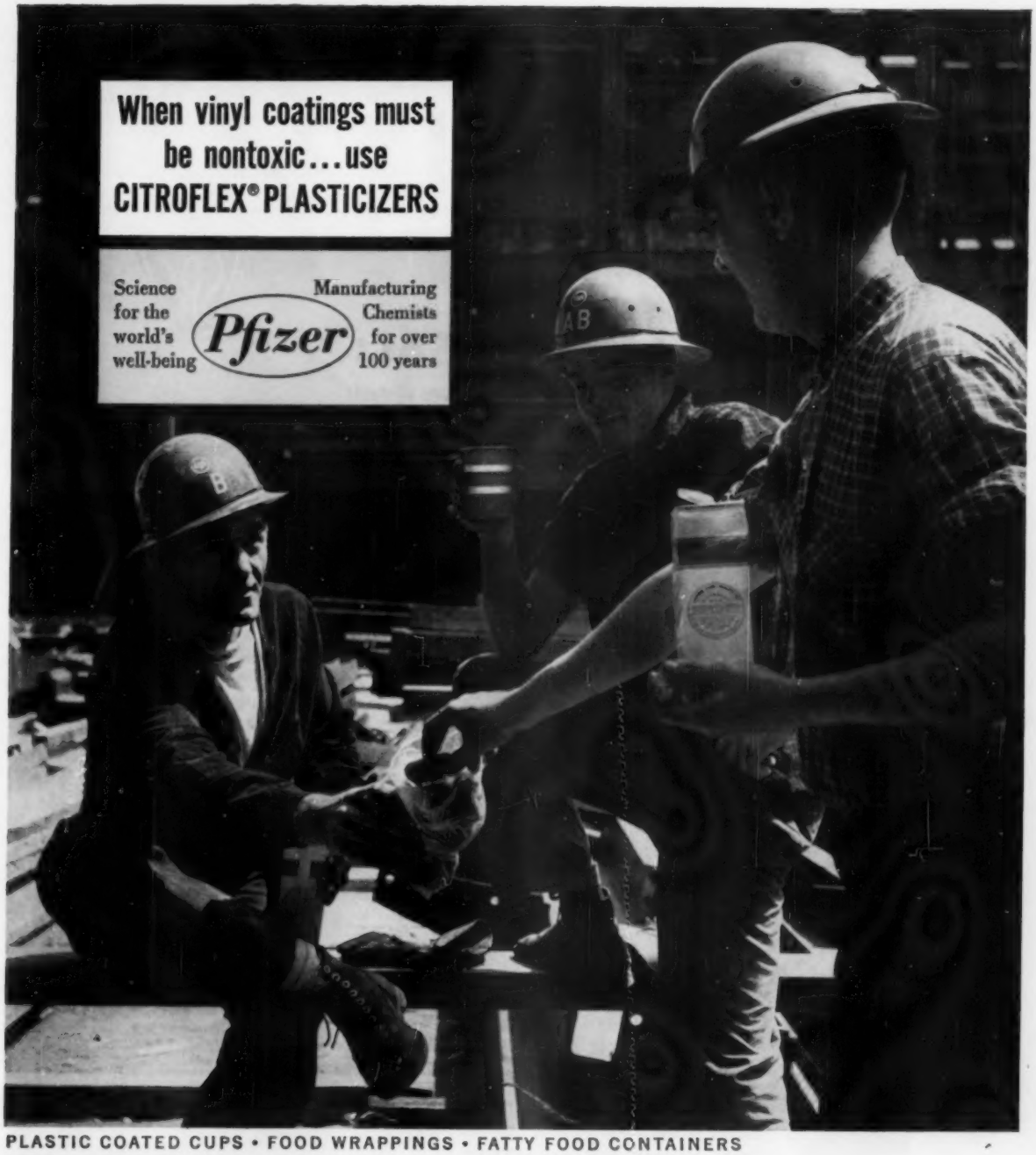
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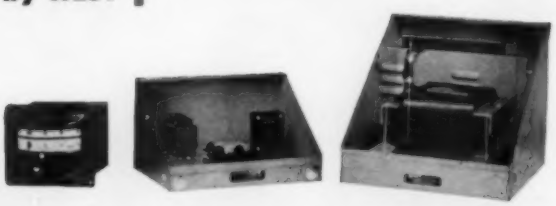

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SPE JOURNAL

plastics engineering trends of technical *significance*

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The Cover

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Daylight With Ejector Box Removed (in.)	29	42
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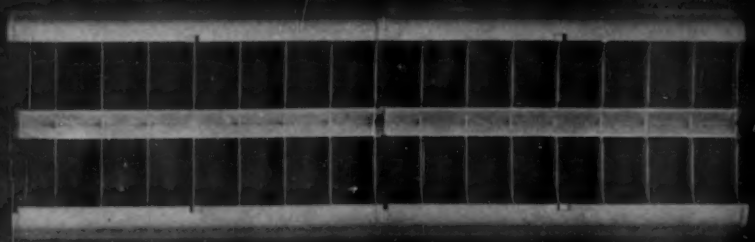

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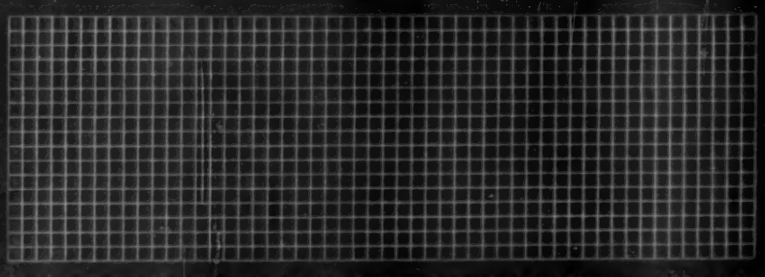

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EDITORIAL

The Magic Date

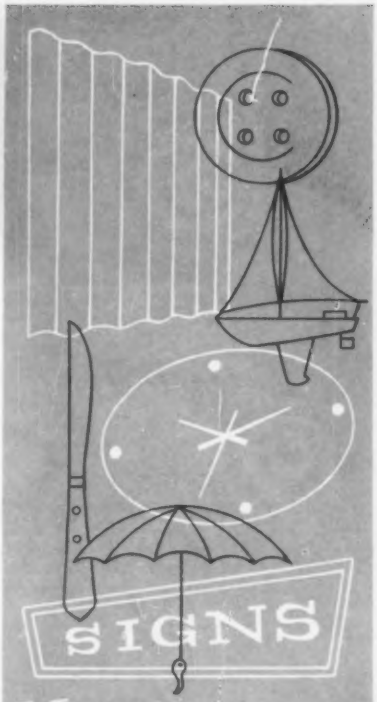
The magic date we speak of in our title is March 5, 1960. That is the date when the Food Additives Amendent of 1958 becomes effective, bringing with it important technical ramifications of vital concern to the plastics engineer. It is the date when makers of plastics films, coatings, adhesives, stabilizers, lubricants, plasticizers, fillers and extenders, or anything else that goes into plastics used for packaging foodstuffs will be in a serious race to get the stamp "FDA Approved" on their products.

John Kuniholm of Hercules Powder Company's Legal Department told an audience at SPE's National Technical Conference in Los Angeles in October: "I don't believe there will be any widespread seizure of plastic materials. But I suspect there's going to be a widespread switching from materials surrounded by question marks to those on which FDA has bestowed its approval."

What are likely to be some of the effects of the Amendent? Several are readily apparent. It more than likely spells doom for plastics scrap for food packaging materials; it will narrow down the selection of raw materials; new product development "lead" time will be much longer.

What can manufacturers do? Mr. Kuniholm states that a step by step approach is best. First step is to weed out the low volume formulations whose sales do not justify further attention. Next take a look at raw materials. If you are using twenty, you may find you can get along with fifteen. An experienced toxicologist can help here. Having narrowed the problem, take the one formulation most important to you, run an extractive study on the individual material as it comes from the extruder or mold. The next step is to run down each of the components that migrates. FDA officials have promised to publish a list of migratory components recognized as safe. If your migrant is on this list, your problem is solved. If not, you've got re-formulation work on your hands.

The saying goes, forewarned is forearmed. We think that the two articles in this issue, pages 201 and 203 go a long way in spelling out what FDA requires for clearance, how to file for clearance, and what chemicals already are approved. We strongly recommend these articles for your reading responsibilities. It has been said that industry needs more time than the March 5 deadline. These articles present an opportunity to get "updated" in a half hour.



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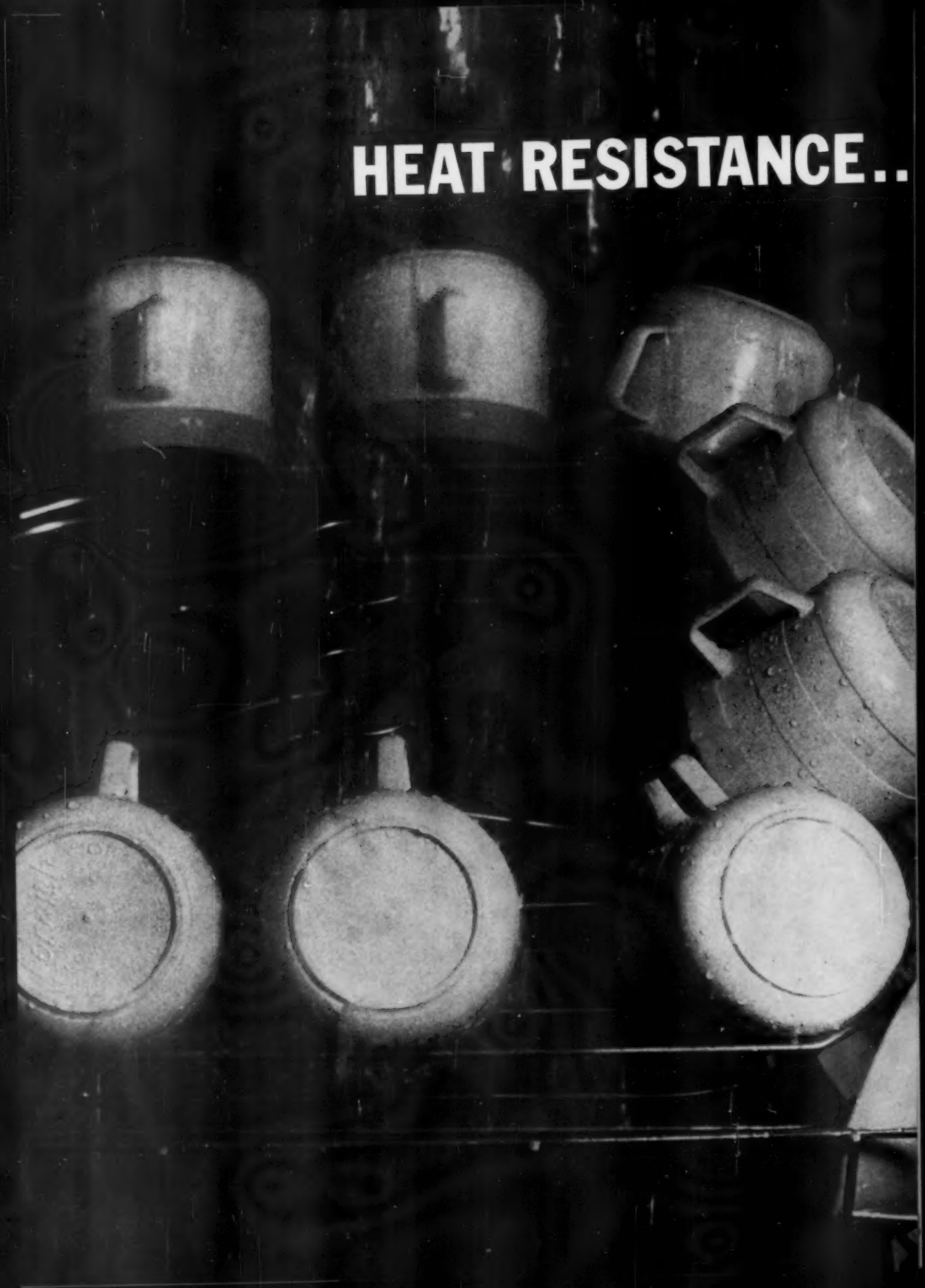
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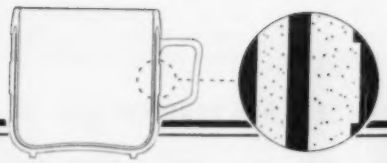

Cutaway showing construction of Cornish Therm-O-Coffee cup. Insulation space permits comfortable handling regardless of temperature of the contents. Molded by Bopp-Decker Plastics Company, Clawson, Mich. for Proven Products Corp., Skokie, Ill.

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Secant Modulus (Stiffness), psi	D 638-58T	100,000
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Ultimate Elongation, %	D 638-58T	45
Tensile Impact (ft. lbs./cu. in.)		50

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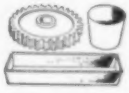

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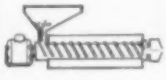
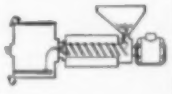


Constant cross sections of indefinite length. Films, sheeting, profiles, laminates and coverings are made in this manner.

CENTRIFUGAL CASTING

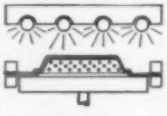


Forms massive cylindrical parts of infinite variety. Economical particularly for small quantity orders.

BLOW MOLDING

Provides hollow, thin-wall items of virtually any closed shape. Bottles, toys and novelties are common.

VACUUM FORMING



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Heat sealing, welding, positive joining used to form shapes and films into complex products.

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SPE JOURNAL NEWSLETTER

reading time
1 minute

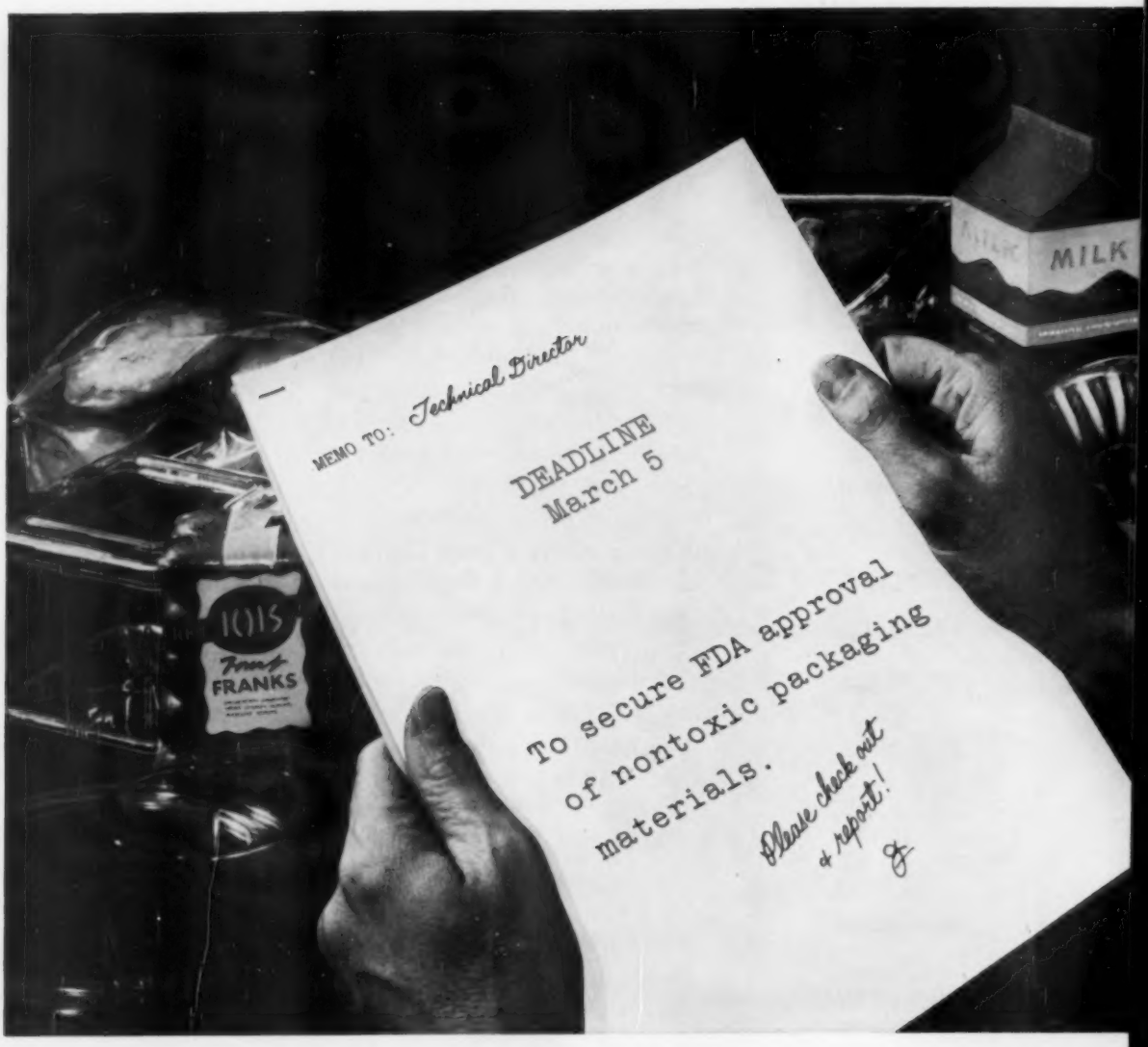
Plastics for Food Packaging Put to the test

Food and Drug Administration's newly-amended Food Additives law becomes effective March 5, 1960. The new law will require that, if migratory components are present in plastics films used for packaging food, those components must be approved by FDA as non-toxic (pages 201 and 203). Other recent articles: Appraisal of the Safety of Chemicals in Food, by Lakey, Safety of Packaging Materials, by Kirk, and Establishing Tolerances for Food Additives, by Rankin. . . . The New York Times has started a revolution in the packaging of newspapers for mailing. Each Sunday edition bound for subscribers in California, Washington, and Illinois is packaged in transparent polyethylene bags. . . . Technical note to the "lab" man—a unique way to get a "delayed" chemical reaction is to place one reactant in an injection molded ethylene oxide polymer water-soluble container. When this container with reactant is added to another, the container is dissolved, and the desired reaction takes place. . . . A new type of industrial adhesive is now on the market. It's a dry phenolic resin supported by a paper film. Big advantage is the need for glue spreading equipment is eliminated. . . . Everybody is familiar with the use of plastics in printed circuits. But an even more ingenious idea is in the offing—molded-in plumbing and electrical lines in plastic wall panels for homes. The units will be so designed that when the panels butt up against each other, the connection will automatically be made. . . . Having trouble getting heat out of a molding cavity? Here's a trick that might help you. Coat the outside of the force plug with electroplated hard copper. . . . Processing behavior of vinyl homopolymers can be improved by admixture with 5 to 10% of a specially designed acrylic polymer. The processing improvement is achieved without sacrificing any of the original properties of the vinyl resins.

Plastic Bags for The New York Times

Molded-in Plastic Plumbing

Acrylic Modifier for Vinyls



Simplify evaluation work. Specify use of **MONSANTO'S**

SEVEN FDA-APPROVED PLASTICIZERS

The 1958 Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act requires extensive evaluation of many plastic packaging ingredients . . . including extraction tests, and possibly expensive, time-consuming spectrophotometry, radioactive tracing, and animal-feeding tests. Specification of a Monsanto *approved plasticizer* can help you minimize this problem.

Seven Monsanto plasticizers approved for nontoxic applications can give you more assurance of meeting FDA specifications—and also provide a broad range of properties to meet the most particular packaging requirements. *Five* Monsanto plasticizers (SANTICIZER 141, SANTICIZER E-15, SANTICIZER B-16, Monsanto di-isobutyl adipate and diethyl phthalate) have earned *complete acceptance* from the FDA for use in plastic packaging for aqueous, fatty or nonfatty foods.

By specifying use of these Monsanto *approved plasticizers*, you can be more certain that your packaging materials are toxicologically safe and comply with the 1958 Food Additives Amendment. Check the tables shown here. They're a convenient guide to industry's largest and most diversified line of plasticizers for nontoxic formulations . . . from Monsanto. For more details and a copy of the 1958 Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act, just use the convenient coupon.

Plasticizer compatibility with six plastic materials

Monsanto Plasticizers	Polyvinyl Chloride	Polyvinyl Acetate	Cellulose Acetate	Ethyl Cellulose	Acrylic Type	Nitrile Rubber
Santicizer 141	C	C	SC	C	C	C
Santicizer E-15	C	C	C	C	C	—
Santicizer B-16	C	C	LC	C	C	C
Di-isobutyl Adipate (DIBA)	C	C	I	C	C	C
Diethyl Phthalate	LC	C	C	C	C	C
Dioctyl Phthalate (DOP)	C	SC	I	C	SC	C
Di-isoctyl Phthalate (DIOP)	C	SC	I	C	SC	C

C (Compatibility)—25-100 parts per 100 parts resin. LC (Limited Compatibility)—10-50 parts per 100 parts resin. SC (Slight Compatibility)—1-25 parts per 100 parts resin. I (Incompatible)

Job-rated plasticizer performance (where "1" is best, based on typical results)

Monsanto Plasticizer	Non-Toxicity	Low Volatility	Grease & Solvent Resistance	Water Resistance	Low Temperature Flexibility	Low Cost
Santicizer 141	1	1	1	2	2	1
Santicizer E-15	1	4	1	3	3	2
Santicizer B-16	1	2	2	3	3	2
Di-isobutyl Adipate (DIBA)	1	3	2	3	1	2
Diethyl Phthalate	1	5	1	2	3	1
Dioctyl Phthalate (DOP)	X	1	3	1	2	1
Di-isoctyl Phthalate (DIOP)	X	1	3	1	2	1

X—Accepted for use with foods of high water content only.

FOR NONTOXIC PLASTIC APPLICATIONS

Informative Booklet on Nontoxic Plasticizers

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Gives specific advantages in numerous applications, describes outstanding features and lists specification properties of seven Monsanto nontoxic plasticizers. For your copy, use the convenient coupon.

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MONSANTO CHEMICAL COMPANY
Organic Chemicals Division
Plasticizer Dept. 1D, St. Louis 66, Missouri

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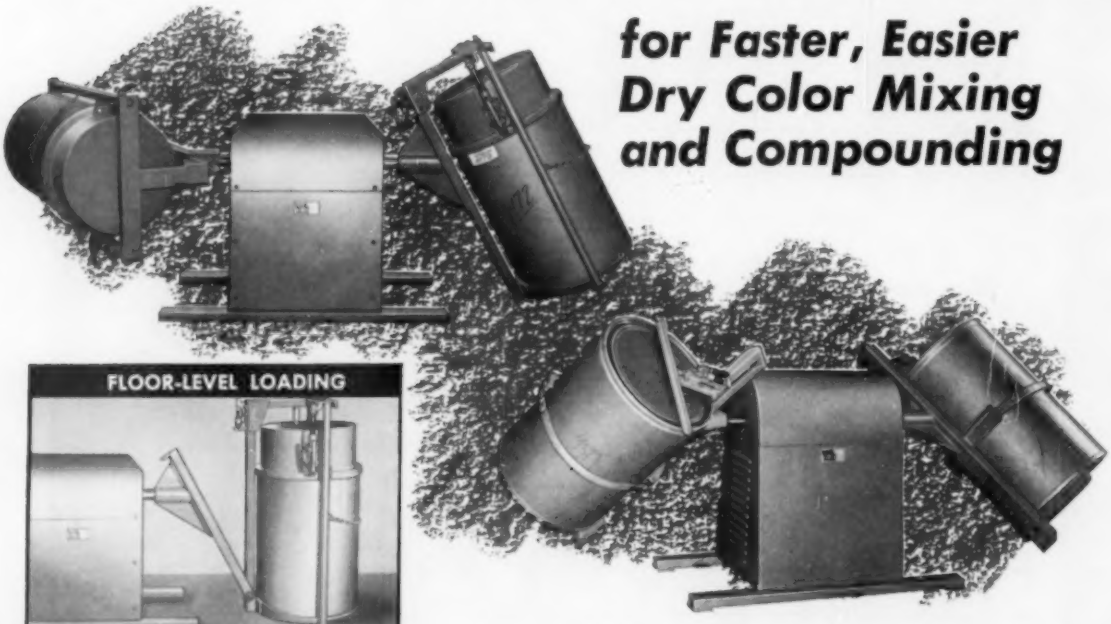

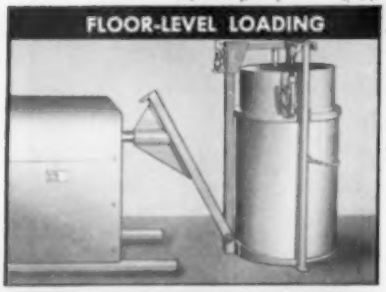

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These precision-built machines have sturdy welded construction for long life and trouble-free service. Their rugged steel bases provide rigid support for handling unbalanced loads. Positive roller chain drives, extra powerful motors and heavy-duty ball bearings assure smooth tumbling action under heavy loads.

Only "U. S." Drum Tumblers offer such extra ease of operation. Custom-built to meet specific mixing requirements, they are available with typical features shown at left — "floor-level" loading for quicker, easier drum handling; built-in drum extenders, providing extra space for thorough mixing of full drum loads; quick-acting toggle clamps for rapid opening or closing in one easy motion; adjustable drum holders to handle various size drums.

"U. S." Drum Tumblers are built in a range of sizes to handle standard fiber or metal drums; with motors of ¾, 1, 2, 3, and 5 h.p.; capacities from 250 to 500 lbs. per drum. Our Engineering Service Department will gladly recommend the proper unit to meet your specific mixing requirements. Write today for complete details.

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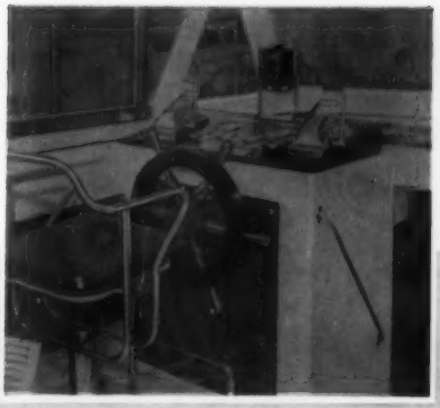

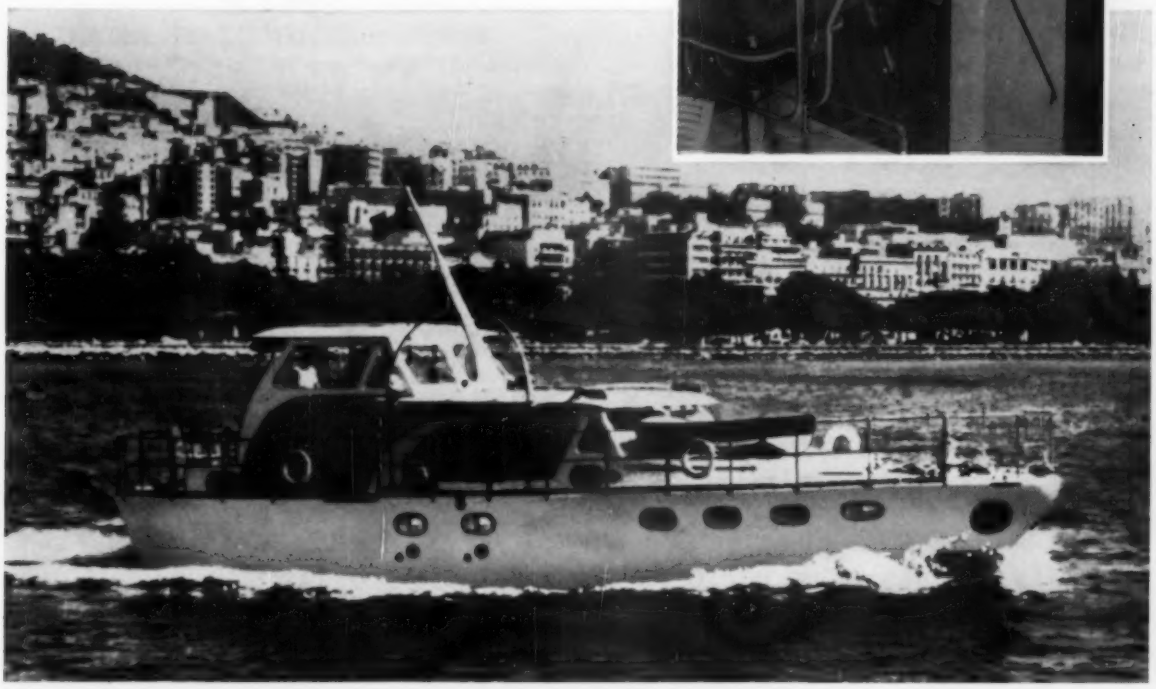

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● This is the custom-made "CELUANG", built of glass fiber reinforced polyester — by Resine Sintetiche Ed Affini, Naples, Italy.

Inside and out, RCI Resins serve . . . POLYLITE 8001 in the hull, superstructure, deck, partitions, doors, appointments — and POLYLITE surfacing resin in painting and finishing applications. Further evidence that boat builders everywhere choose RCI polyesters.

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Rugged strength. That makes boats extra safe . . . to withstand severe impact and resist cracking.

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Superior wetting-out properties. Insure that fibrous glass material is always thoroughly impregnated with strength-giving resin.

Handsome appearance. Hulls, decks and superstructures are sleek, chip-proof and virtually maintenance free.

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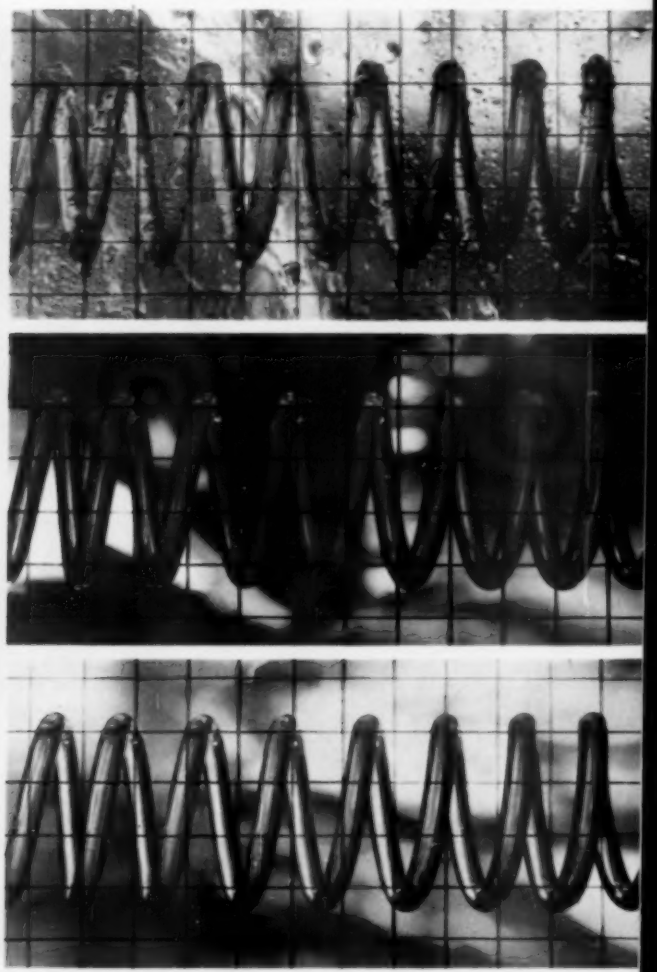

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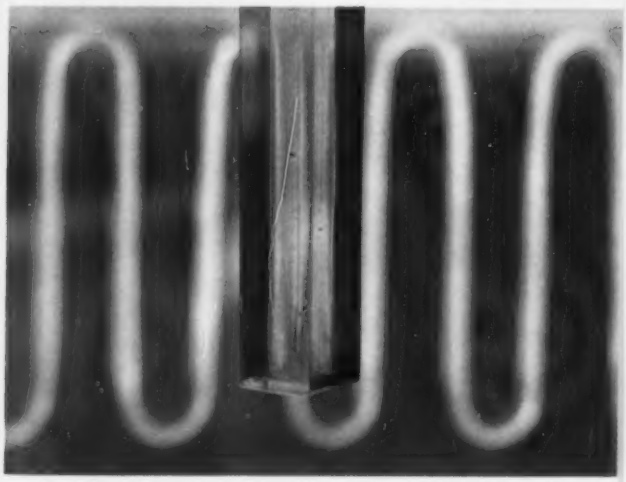

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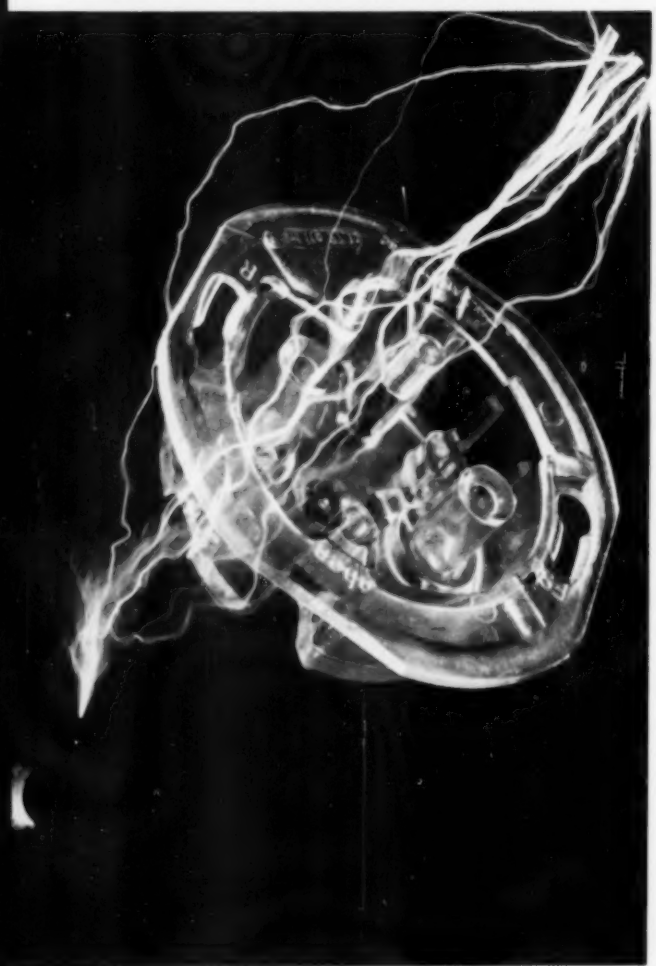
(Example: 440 volts/mil dielectric strength, short time—see table)



PROPERTY
MECHANICAL
Impact strength, Izod (notched)
Tensile strength and yield point
Elongation, at yield
Elongation, ultimate
Compressive stress at yield point
Deformation under load
Flexural strength
Modulus of elasticity Tension Flexural
Rockwell hardness
ELECTRICAL
Dielectric constant 60 cycles 10^6 cycles
Dielectric strength, short time
Dissipation factor 60 cycles 10^6 cycles
Volume resistivity Dry 4 days at 80% rel. humidity
Arc resistance

ard equipment. Finished parts have brilliant surface gloss, can be machined, sawed, cut or stamped; easily bonded with appropriate solvents; readily heat welded or sealed. Plasticizers are not necessary; dyes and pigments can be added for a full range of transparent or opaque colors.

Examine MERLON's qualifications shown in the chart under the flap of this advertisement—check it against "problem" materials you may now be using. It's very possible that MERLON is the optimum material you've been
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lower cost and improv
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cation data and proper
five years of research
abroad) are available. M

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CARBONATE

PROPERTIES OF MERLON® POLYCARBONATE RESIN

	ASTM NO.	VALUE*
	D-256 (½" x ½")	2 to 3 ft-lb/in.
	(½" x ⅛")	12 to 16 ft-lb/in.
	D-638	8,000-9,000 psi
	D-638	5-6%
	D-638	60-100%
	D-695	12,000 psi
	D-621	0.14%
	D-790	11,000-13,000 psi
	D-638	2.8-3.2 x 10^5 psi
	D-740	3.2-3.4 x 10^5 psi
	D-785	R 115
	D-150	
		2.95
		2.90
	D-149	440 V/mil
	D-150	0.0007
		0.0100
		1.2 x 10^{16} ohm/cm
nidity		9 x 10^{14} ohm/cm
	D-495	12 sec

PROPERTY	ASTM NO.	VALUE*
THERMAL		
Heat distortion	D-648	
264 psi		280°F
66 psi		290°F
Specific heat		0.28 cal/°C/gm
Coeff. of expansion	D-696	7 x 10^{-5} in./in./°C
Melting temperature		425-440°F
Crystalline melting temp.		505°F
Flammability (in./min)	D-635	Self-extinguishing
MISCELLANEOUS		
Specific gravity	D-792	1.20
Refractive index	D-542	1.587 N_D25°C
Clarity		Transparent
Water absorption 24 hr immersion	D-570	0.3%
Effect of sunlight		None to slight
Outdoor aging		Good

*These values have been obtained under standard ASTM and laboratory test conditions. As averages, these values do not necessarily represent minimum material specifications.

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NOW IS THE TIME TO SUBMIT PAPERS FOR THE 17TH INTERNATIONAL ANTEC

PLASTICS ENGINEERING is maturing rapidly from a collection of arts into a recognized profession of ever-increasing worldwide importance. It is quite appropriate, therefore, that the 17th Annual Technical Conference of our Society is to be held in Washington, D. C., this nation's capital, and it is to be international in scope.

The plastics engineer's responsibility, as a professional, is to make correct decisions. But the rapid obsolescence of ideas and the competition among the growing numbers of individuals in the field makes it difficult for him to keep abreast of new developments or inform others of his work.

One excellent way to gain information is to attend our fine technical conferences as so many did in Chicago, last month. Also, one way to gain recognition is to present a paper at an Annual Technical Conference with the goal of winning an award for "Best of ANTEC". The next major opportunity to achieve both of these ends will come with the 17th ANTEC in Washington.

In planning an international technical conference, great care must be taken to insure that the sessions and papers are of the broadest interest and highest quality. It is important also to give opportunity to all hopeful authors including our colleagues in foreign lands who may wish to select this occasion to visit our country to exchange ideas.

Previous ANTEC Committees have found that the selection of papers on the basis of brief preliminary abstracts is at best a risky business. In line with the newly established policy of the Meetings Committee, this year's Speaker's Committee is now soliciting long abstracts, complete with whatever data are to be included in the paper. These will serve as a basis for preparing a general outline of sessions. Final selection of sessions and papers will be based on a detailed review of manuscripts by recognized experts who will be selected from all quarters of our Society.

The papers should be novel, not heretofore presented or published elsewhere, and of maximum scientific, engineering, artistic or crafts interest in the field of plastics. If accepted for presentation the publication rights for the papers will be the property of the Society.

Previous ANTEC Committees have also found the usual program planning timetable too close to permit adequate review of manuscripts as they arrived. Therefore the 17th ANTEC Speaker's Committee is encouraging hopeful authors to draft their papers now and to submit their abstracts and manuscripts at the earliest moment. The committee has already established personal contact with all of our very competent and rapidly growing Professional Activities Groups. With their help, the committee is making this solicitation a month earlier than usual.

Under this year's timetable, abstracts must be submitted on or before 1 April, and final manuscripts must be delivered on or before 15 August. This allows two months for expert review and any corrections by authors before delivery to our Executive Office for printing in the Pre-print Book.

The abstracts submitted should be 300 to 1000 words in length and should contain enough information and data, even though it be in rough form, to give a clear indication of the scope and contents of the proposed paper. All abstracts and communications concerning papers for this conference should be directed to the undersigned.

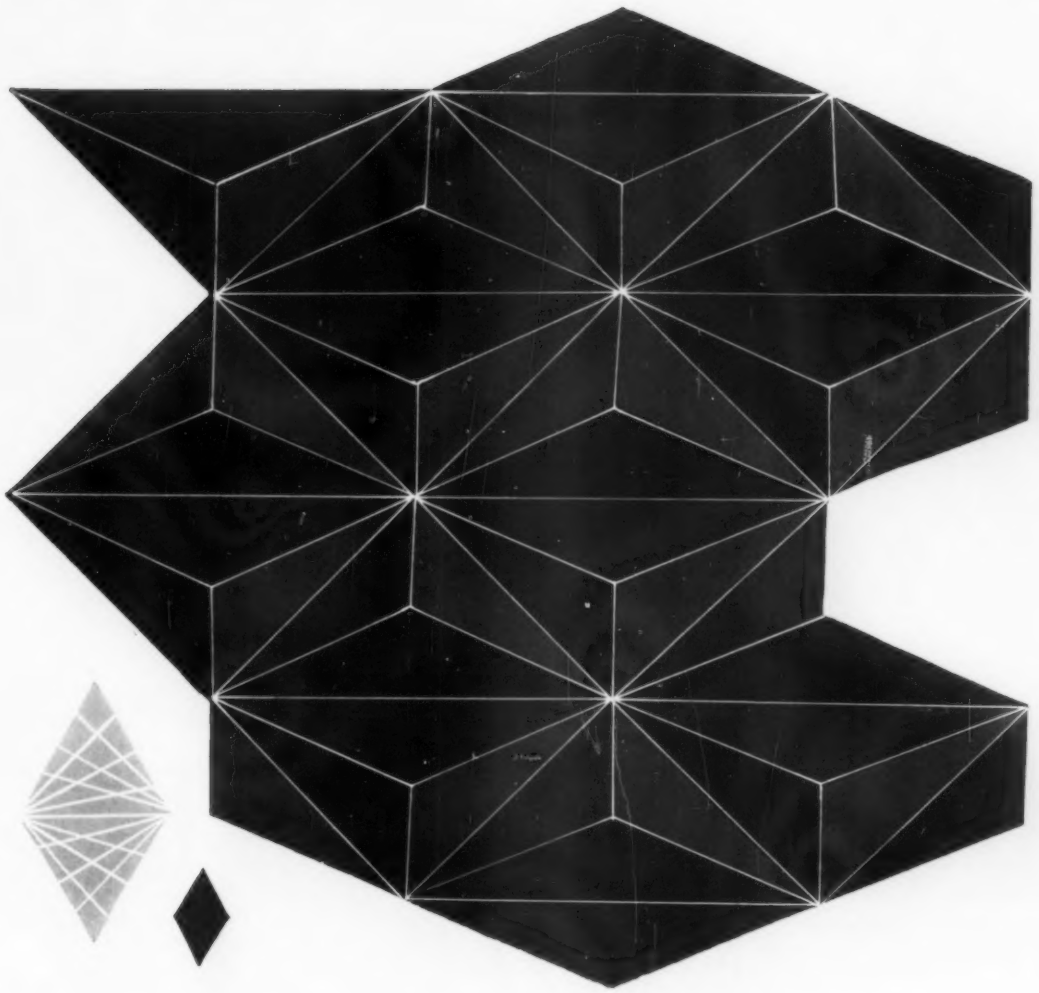
All sessions will be planned to arouse the greatest range of interest. No sessions will be included unless an adequate selection of excellent papers are available for it. If you are a member of a Professional Activity Group, send a copy of your abstract to the Chairman of your PAG. In this way the PAGs, who will play a very important role in the review and selection of papers, will be kept informed concerning the activities of their members.

We are gratified with the enthusiastic response of the PAGs. With their help and the help of everyone else, your 17th ANTEC Committee, under the leadership of Dr. Gordon Kline, hopes to make this an international event of some importance and the greatest Annual Technical Conference in the history of the Society of Plastics Engineers.

H. A. Perry, Chairman, Speaker's Committee, 17th ANTEC—1961

Address correspondence to:

H. A. Perry • c/o Naval Ordnance Laboratory • White Oak, Silver Spring, Md.



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Key people at the President's Reception. Left to right, Raymond E. Daniels, Jr.; 1959 President, Chicago Section; Franklin L. Fine, General Chairman, 16th ANTEC; Frederick C. Sutro, Jr., 1959 SPE President, George W. Martin, 1960 SPE President Frank H. Carman, Technical Director, Manufacturing Chemists Association.

Technical News Highlights of the 16th Annual Technical Conference

Jesse H. Day,

Chairman, Dept. of Chemistry,
Ohio University, Athens, Ohio

and NEWS OF THE MEETING IN PICTURES

In a general way, papers at the 16th Antec reflected the status of plastics engineering—greatest interest was in the two allied fields of practical molding practice and new and easier test methods to characterize molding behavior of the various plastics.

The polyethylenes occupied center stage at SPE's 16th ANTEC, with papers in all fields—but particularly in practical molding and extrusion, mold design and mold flow. New and more meaningful test methods to characterize physical properties and molding behavior were notable for their simplicity and practical usefulness. Theory of flow behavior was advanced significantly and much attention was directed to finding a better guide to polymer behavior than the melt index.

POLYETHYLENE

Calculations Provide Crystal Ball for Molding Conditions

A simplified analysis of the variables during the actual flow of polyethylene into the mold provides a guide concerning the effects of mold dimensions, mold fill-out patterns, and other variables. Equations relating the principal variables are shown in the box above. The simplifying assumption that mold pressures may be calculated from the equation derived for extrusion die pressures proves to be accurate for polyethylene, according to the work of R. B. Staub of Union Carbide Plastics Co. (*21*).*

Flow into the die is directly proportional to pressure at the mold gate, and inversely proportional to the effective viscosity and to the die resistance. The effective viscosity is itself actually a variable, being a function of rate of shear to the −0.6 power (thus a function of rate of mold filling—the faster the fill, the smaller the value of the effective viscosity). The mold resistance K is a constant, whose value depends on the particular die under consideration.

The value of K varies with the mold fill-out pattern; examples are shown in the box (p. 162), revealing that rate of mold fill depends on the length, the width (or circumference) and the third power of the part thickness. Too small gates, or very thin parts, greatly increase the pressure needed to fill. Shape of the die involves another effect; if the fill out pattern is circular, the pressure to

* Numbers in parentheses indicate paper number as given at ANTEC.

◀ Overflow at registration . . . .

Past Presidents' Advisory Board Meets. Chairman R. Kenneth Gosset (1958) reads report to luncheon meeeting of Board. From left to right, seated, with year of Presidency in parenthesis; SPE President George W. Martin. Frank W. Reinhart (1955); Frederick C. Sutro, Jr., (1959); W. O. Bracken (1952); John W. LaBelle (1954); Walter F. Oelman (1953); Standing, left, J. Harry DuBois (1948); right, Islyn Thomas (1959). Mario J. Petretti (1949) and Jerome L. Formo (1956) also participated in the meeting. ▼

▲ President Sutro presents Distinguished Member certificate to Charles C. Henry, 1944 SPE President, earliest Past President at the 16th ANTEC.

SPE members at the Education Luncheon hear Dr. Ralph A. Morgen, President Rose Polytechnic Institute, speak on "Trends in Engineering Education as they Affect the Plastics Industry." ▶

fill increases exponentially with die width (radius). For example, a rectangular dishpan has a circular fill out pattern till its sides are reached (pressure is exponential function of radius), then the fill out assumes a tubular pattern, (pressure given by equation above).

Figure 1. Simplified Analysis of Injection Mold Filling of Polyethylene

EXTRUSION

Die Pressure = flow rate (in^3/sec) x effective viscosity (lb-sec/in^2) x die resistance (in^3)

$P = Q N K$

INJECTION

Pressure at Mold Entrance = flow rate (in^3/sec) x effective viscosity (lb-sec/in^2) x mold flow resistance (in^3))

$P = Q N K$

Values of K may be estimated

(1) For a rectangular fill-out pattern
$K = 12 \times$ cavity length (in./cavity width (in.) x cavity thickness $(in)^3$

(2) For tubular fill-out, such as wall of a tumbler
$K = 12 \times$ cavity length/mean circumference x cavity thickness^3

Want to Increase Toughness of Molded Polyethylene?

Toughness of injection molded polyethylene is improved by reducing orientation through slower injection speeds, thicker wall sections, multiple gating to reduce distance of flow, short plunger dwell time and low hold pressure. Faster cooling rates are best obtained by lower mold temperatures and longer mold closed times. These recommendations were based on work with a 0.926 polyethylene of melt index 20, performed by W. T. Wickham, Jr., W. A. Dunlap and P. J. Meeks, of Dow Chemical Company (*46*).

Toughness and serviceability of high density polyethylene housewares was the subject of a study by Jones, Scott and Boeke of Phillips Chemical Company (*45*). They studied the effect of molding conditions on an eleven inch salad bowl and found that the mold surface temperature was the most important single factor affecting toughness. A low mold temperature (65°F) produced the toughest parts; the same mold at 180°F produced brittle parts. Starved feed produced better bowls, pointing up importance of accurate feed control mechanisms. Toughness is best with the feed at the highest temperature that does not overheat the mold, and with a mold that has a large enough gate to allow rapid filling and minimize orientation of the polymer.

Vacuum Forming Made Easy

Male and female drape forming of 0.96 density linear polyethylene demands close temperature control and dies capable of good heat transfer. R. Doyle and D. E. Allison, Phillips Chemical Company (*63*), summarized their experience in the search for best forming methods. They report that aluminum molds give the best heat control, when properly channeled, and release properties. Parts for a 25" x 25" light diffuser were molded with a tolerance of 0.009 inches, in a mold controlled to within two degrees F. Temperature control over the whole piece is important, since a 25 degree variation in mold temperature could alter the length of a 10" piece by more than 1/16". Satin or textured finish of the mold aids in mold release.

The holes in the mold must be smaller than usual, because of the low melt viscosity of linear polyethylene. Recommended sizes are 0.0210" to 0.0135" holes. These may lead to larger holes to facilitate rapid draw.

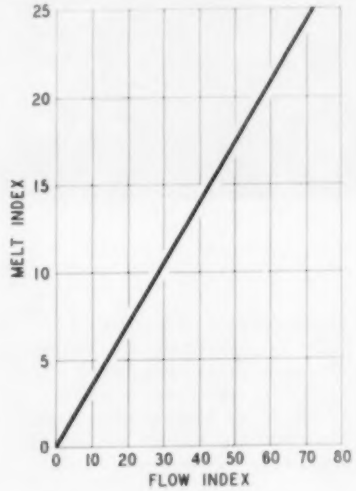
Shrinkage factors obtained are much better than those previously reported by others, giving in the worst case a maximum of 3½% with an average of 2 1/5% to be expected.

Index to Polyethylene Flow

The melt index is not a reliable guide to polyethylene flow characteristics or physical properties unless the resins are compared under the same processing conditions and have similar molecular weight distributions. For example, two polyethylenes of similar melt index and density differed in flow index (29.9 and 9.6), brittleness temperature (80°F and −180°F), and in impact strength by a factor of 2. The "Melt Index Equivalent" is a better standard by which to compare resins of different molecular weight distributions. The MIE, developed by R. J. Martinovich, P. J. Boeke and R. A. McCord of Phillips Chemical Company (*30*), consists of determining the flow index of a resin and relating it to a standard reference melt index vs flow index curve. The melt index on the standard curve corresponding to the flow index of the material in question is designated as its melt equivalent index.

The reference curve is based on fundamental property of molecular weight distribution; the ratio of flow index to melt index was determined for a resin of Mw/Mn ratio of 10. The ratio of MIE to melt index depends on the mol. wgt. distribution. For a resin to be investigated, the flow index of the resin is determined, that point found on the reference curve, and the corresponding value

16th and 17th ANTEC Executive Committees exchange information. Left to right seated: Frederick C. Sutro, Jr., 1959 SPE President; Franklin L. Fine, General Chairman, 16th; Gordon M. Kline, General Chairman, 17th; George W. Martin, 1960 SPE President; and Thomas A. Bissell, Executive Secretary. Standing: Raymond E. Daniels, Jr., Treasurer, 16th; Frank W. Reinhart, Vice Chairman, Arrangements, 17th; Charles M. Waugh, Vice Chairman, Program, 16th; George W. Flanagan, Secretary, 17th; Gibran M. Baccash, Vice Chairman, Arrangements, 16th; Kenneth A. Kaufmann, Speakers Chairman, 16th; Albert Lightbody, Vice Chairman, Program, 17th; and H. A. Perry, Jr., Speakers Chairman, 17th.



of melt index is taken as the melt index equivalent.

Guide to Successful Polyethylene Extrusion

Melt viscosity has a direct relationship to the shape retaining properties of linear polyethylene in the hot draw state—a melt index of 0.2 to 0.4 is recommended for most profiles and tubes. The work of D. J. Schmidt of W. R. Grace & Company (*49*), has revealed the best conditions for extrusion of linear polyethylene profiles. These include; use a long barrel extruder with a L/D ratio of 20/1, with a constant pitch metering type screw with four metering flights, and use a melt temperature range of 330 to 350°F. Draw ratios should lie between 1.2 and 1.5. A most critical phase is proper design of the sizing plates, which should be of metal with high heat transfer properties. The plates may total five, with the second and third plates adjustable in the axis parallel to the extrusion, and all directly in line at all times. Pipe haul-off equipment serves for the take off.

Presentation of 1959 President's Cup by Frederick C. Sutro, Jr., to George B. Baron (New York Section) for outstanding service to the Society.

Colored Polyethylene Better Than Natural?

Properly pigmented and compounded linear polyethylene can have better properties than the unpigmented material, and the inorganic pigments normally used for low density polyethylene are suitable for the linear material. These conclusions were reported in the work of Campbell, Martinovich and Gay, Phillips Chemical Company (*75*), but they point out a number of variables which need to be taken into account. Method of dispersion of pigment is important, and is affected by the pigment loading desired; for example, coloring during injection molding will be best if the pellet size is small, the gate is pin-point, the melt index of the resin as low as possible, and dispersion plug of the Venturi type. Metallic effects can be used provided the reactive metal bits do not react with the pigment, and the metal should be withheld until the last possible phase of the processing is run. High loadings of metallics may affect impact strength.

One unexpected result of their work indicated that there may be a deterimental reaction between some pigments and the base resin. Phthalocyanine blue caused warping of sheets and drastically reduced thermal stress crack resistance.

New Test Measures Polyethylene Degradation

Extent of polyethylene degradation has been measured by melt index values. A more reliable test, useful over a greater range, is the ZST (zero strength time) test, described by T. H. Meltzer and J. J. Muldrew of the Electric Storage Battery Company (*6*). The ZST test consists of putting a standard notched test strip vertically in an oven with a standard weight attached and measuring time to rupture at the notch. A load of 7.5 grams at 130°C gives a zero strength time of around 200 seconds. Sample thickness at the notch of the compression molded sample is set at 62.5 mils.

Copolymers for Squeeze Bottles

The copolymer of ethylene with 1-butene has exceptional environmental stress crack resistance and load bearing properties, being superior to any of the polyethylenes in these respects, yet they have also the desirable properties of the homopolymer as well. The work of J. E. Pritchard, R. J. Martinovich and P. J. Boeke, Phillips Chemical Company (*54*), has demonstrated these properties and suggested copolymer use especially in squeeze bottles, insulation, filaments and pipes. An interesting sidelight is that a squeeze bottle partly filled with detergent fails more rapidly than a completely filled bottle; stress-crack tests thus should specify partial or complete exposure to the testing agent.

Intermediate Density Polyethylenes

Ethylene copolymers of 0.93 and 0.94 density show properties not possible in the regular polyethylenes, and represent a real breakthrough in polymer properties. They are able to withstand sterilization and have exceptional impact strength together with stress crack resistance better than that of linear polyethylene. E. T. Pieski, S. H. Jenkins, Jr., and S. P. Foster, E. I. du Pont de Nemours Co., Inc. (*52*), pointed out that most of the apparent difficulty in making wire cable extrusions can be solved simply by making minor changes in the geometry of the wire guide which fits inside the die, or to switch from the conventional pressure die to the tubular die which is more common in nylon extrusion.

POLYPROPYLENE

Polypropylene molding, extrusion, structure and physical properties showed the rapid development and wide potentialities of this newcomer.

Equipment for Polypropylene Film Extrusion

The quality and properties of polypropylene film do not depend greatly on processing conditions, so that for major changes in film properties, the resin must be changed through manipulation of either the stereoisomer distribution or the molecular weight. For example, a resin with higher isotactic content has a lower friction, higher gloss and lower film impact strength. These were some of the main points derived from experiments conducted by G. C. Calderwood of Spencer Chemical Company (*24*), who recommended equipment for polypropylene film extrusion; long barrel—20/1 L/D ratio gives 10 pounds more per hour output in a 2.5 inch extruder—high screw speed, use of the full range of take-off speeds since polypropylene draws-

down very well, coat-hanger type dies.

A Rope That Can Take It

Polypropylene monofilments will be strongest when processed at optimum conditions, which were determined by G. L. C. McIntyre, W. C. Craven and W. E. Heumann of Enjay Company (72). While each processing condition may have a relatively minor effect, the proper control of all conditions can make a difference of more than five times in strength. The strongest fibers are made from low melt index resin of high density, extruded at relatively low melt temperatures and high orientation temperatures, using a warm quench bath, and cold drawing. A low melt index resin gave filament of 8 grams per denier at 425°F stock temperature, 350°F orientation oven temperature and 130°F bath.

VINYLS

Vinyls came in for their share of attention with papers on formulation, testing and stabilization, new methods of application.

Acrylic Modified Vinyl Resins

Rigid and semi-rigid vinyl formulations can be more easily processed with no loss in desirable properties when a specially prepared acrylic polymer is incorporated to the extent of about 15 to 25%. Handling on the mill is facilitated and extrusion is much easier. Acrylic modification of high impact vinyl results in a great increase in Izod notched impact strength. Processing stability of a mixture is good, and scrap can be recovered and used. These conclusions were reported by R. P. Hopkins, Rohm and Haas Co. (*59*), who pointed out also that the lightly plasticized high impact vinylacrylic compound represents a significantly new type of product in the class of rigid vinyl materials.

New and Simple Test for Electrical Grade

A direct and simple method for distinguishing between electrical and nonelectrical polyvinyl chloride resins before formulation has been developed by round robin testing by ASTM Committee D-20 on Plastics, and was reported by J. B. DeCoste (Bell Labs) and B. A. Stiratelli (B. F. Goodrich) (*56*). The method consists of using water extraction of the resin, with some included isopropanol to aid wetting, with measurement of electrical resistance of the resulting solution. Sample size and treatment, quantity of extractant, time of extraction are standardized; increasing extract conductivity correlates well with decreasing insulating ability of the resin.

EXTRUSION THEORY

Extrusion theory dealt mostly with calculations of extruder output, with much experimental evidence to show what actually occurs within the extruder.

1959 Council meets at Chicago. From left to right seated: Thomas A. Bissell, Executive Secretary; Jules W. Lindau III, 2nd Vice President; Frank W. Reynolds, Secretary; Frederick C. Sutro, Jr., President; George W. Martin, 1st Vice President; Haiman S. Nathan, Treasurer. First row standing: Franklin L. Fine, Maurice F. Malone, William F. Utley, Ralph A. Noble, Max M. Lee, Donald W. Biklen, J. Robert Johnson, Sherman M. Crawford, Samuel H. Greenwood, Jerome L. Formo, G. Palmer Humphrey; Second row: John N. Scott, Jr., Joseph B. Schmitt, John Delmonte, James R. Lampman, R. Kenneth Gossett, John F. Kulp, Eugene C. Quear, Albert Lightbody, Frank A. Martin, Carl H. Whitlock, Oscar B. Yorker, and Paul A. West.

Extruder Output

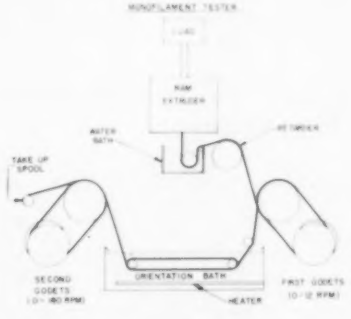
Output from melt extruders is relatively well understood in terms of screw speed and geometry, pressure and viscosity; the case for plasticizing extruders is less well known. To gain insight into the problem, an equation for output was constructed from experimental data by R. J. Donald, J. K. Rieke and E. S. Humes of Dow (*48*). The equation, output = a + bN + cPN + dP, is quite similar in form to the corresponding expression for melt extruders, where a,b,c, and d are experimental constants, P is pressure, N is screw speed. The cross term in P and N is special for the plasticizing extruder.

A Transparent Extruder

A transparent extruder has been built to study melt flow—actually various simplifications are built-in. The barrel rather than the screw revolves, and a transparent Newtonian fluid (corn syrup) was used in place of plastic melt, so that flow lines within the fluid could be photographed. Flow lines were developed by injecting a black fluid from a hypodermic-size nozzle into the melt stream at various distances from the screw axis. The photographs taken for various conditions, output rate, pressure, and the like, give a direct and intimate view of actual fluid flow. This work, by W. D. Mohr, P. H. Squires and F. C. Starr, E. I. du Pont de Nemours Polychemicals Department (*50*), has shown definitely that so long as material is moving through the screw, there is no stagnant zone in the channel, and no material at any time moves toward the rear of the screw.

A Monofilament Tester

Preparation of monofilament for testing usually involves an extruder and the preparation of large quantities of monofilament. To speed matters, J. P. Fogerty and J. J. Whidden of W. R. Grace Company (*23*) have developed a laboratory extruder needing only ten grams of material (30 yards of monofilament) which gives easily controllable conditions of temperature and pressure, plus the feature of easily changing dies used. A schematic diagram of the monofilament machine is shown in the photograph. Time to make a complete run is only twenty minutes.



Plastic is driven into the die by a vertical ram which has the desired weights placed on top. The extruded filament is cooled in a water bath, run over a retarder roll to smooth out fluctuations in draw, led around a Godet roll and through a hot liquid orientation bath in which the

filament is drawn down by the faster Godet wheels at the end, then wound on a spool for use. While the monofilament tester does not duplicate actual commercial production, the tests on the filament give valuable information on trends in properties as functions of degree of orientation, bath temperature and so on. Among results to date is the suggestion that commercial units might be improved to provide orientation ratios of 12/1 to gain greater tensile strength with little change in elongation properties.

REINFORCED PLASTICS

How to Mask PMDA

Higher temperature strength and stability for epoxy resins is possible using pyromellitic dianhydride as the crosslinking agent. Simplified techniques for use of PMDA that overcomes the previous difficulty due to low solubility were reported by R. O. Menard and W. W. Cooner of E. I. du Pont de Nemours Co., Inc. (*29*). Heart of the new process is the reaction of PMDA with a glycol to give new and novel anhydrides that confer the benefits of PMDA with a higher solubility. A sample result is that obtained with PMDA-adduct and Epon 828 glass laminate; result, a laminate with a flex strength of 35,000 psi at 500°F after exposure for 500 hours to the elevated temperature. For wet lay-up laminates the unmodified PMDA gives the same kind of excellent results, with no settling or filtering off the PMDA provided the dispersed particles are 10 microns or smaller; since the available PMDA is 95% in this size range it forms very stable dispersions in liquid epoxy resin. While high temperature resistant resins in general take long cure time, it is possible to make a laminate with the new system which cures in one hour at 250° with no postcure.

Screening Resins for Strength

An accelerated-aging test for polyesters has proven a valuable method of screening resins for use structural parts, and reveals the fact that a simple determination of acid number might be suitable for the same prediction. C. E. Loetel and H. E. Fordyce (The Marley Company, (*28*), investigated the loss of flexural strength of a number of resins, particularly polyesters, on immersions in 200°F water, to find resins suitable for such uses as timber connectors, lath support grids, fan blades and the like. Any resins losing 50% strength in less than 90 days was considered unsuitable. The simple determination of acid number of polyester resins correlates well with the results of the immersion tests, and is valuable at least for a first quick screening of resin; with only one exception among the resins tested, the lower the acid number, the better the long term wet-strength-retention of the resin.

PLASTICS TOOLING

Plastic "Alloy" Overcomes Hurdle

Use of plastics to make molds has surmounted a major hurdle; the fact that plastic is a poor conductor of heat has previously limited its use for molds in which rapid heat dissipation is a must. Lewis Bogart of Marblette Corporation (*16*) described the use of metal fibers in the plastic, and the methods of metal plating the plastic surface, to provide rapid heat conduction. Metal spray faced plastic tools can cycle as rapidly as metal tools and can be made at significant savings. This discussion highlighted a survey of the field of plastics tooling for plastics production.

NEW MATERIALS

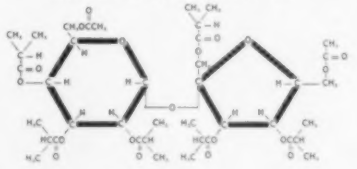
Phosphorus Epoxies

Epoxy plastics capable of withstanding 500°C temperatures are an exciting possibility—certainly they would solve many tough problems in the aircraft and missile field. The route to such epoxy could be through the incorporation of phosphorus atoms into the epoxide molecule. Work on these lines in underway by L. M. Kindley, L. P. Glekas and P. E. Ritts of Melpar, Inc. (*69*). Two main routes are being explored; condensation of epichlorohydrin with organophosphorus compounds, and epoxidation of the double bonds of diallyl and triallyl tertiary phosphine oxides. Though some polymers have been made, principal effort at present is still in the preparation of the organophosphorus monomers.

Sweet Blend Yields Plastic with Harder Surface

Cellulose acetate can now be easily dry blended with the desirable plasticizer dimethyl phthalate, if included in the formulation is some sucrose acetate isobutyrate (SAIB). Now commercially available, SAIB not only eases dry blending problems, but yields a plastic which has a harder surface and which is easier to mold or extrude. SAIB acts also in the role of extender, in that it is somewhat cheaper than the resin it replaces. SAIB formulated cellulose acetate shows an improvement in physical

MOLECULAR REPRESENTATION OF SAIB



properties, especially hardness, and including weight loss on accelerated aging, tensile strength, though Izod impace is somewhat decreased. Development and uses of SAIB were described by W. M. Gearhart and E. W. Wilson of Eastman Chemicals Products, Inc. (*51*).

FOAMS

Statistics in Foams

The effect of formulation variables on the properties of rigid urethane foam (sorbitol-polyether) were investigated in a statistically designed experiment by J. E. Wilson, H. M. Truax and M. W. Dunn of the Atlas Powder Company (*3*). Five variables were investigated; the only factor affecting tensile strength was the isocyanate/hydroxyl ratio, strength increasing as the ratio went from 0.95 to 1.10; shear strength decreases with the ratio, and also is greater for 0.8% catalyst than for smaller amounts; humid-aging was affected only by prepolymer cook time, the longer time decreasing compressive strength; volume change on humid-aging was affected in a complex way by the isocyanate/hydroxyl ratio, with minimum volume change at a ratio value of 105; and none of the formulation variable studied had significant effect on water absorption, per cent open cells or moisture vapor transmission.

THERMOSETTING RESINS

Preform Hardness Helped with RF

Rejects of molded phenolics can be minimized by assuring that the preforms are heated to a uniform temperature. Time and temperature needed depend on the R. F. Electrode setting, but a single setting results in non-uniform heating if the preforms themselves are non-uniform. E. W. Vaill, Union Carbide Plastics Company (*32*), described a simple, dependable test for pre-form uniformity. Size and density of preform correlate with Shore hardness, so that routine control of preform hardness hardness with the inexpensive Shore gauge aide control of production quality.

New Modified Alkyd Molding Compound

New alkyd molding compounds have been created which have a high retention of insulating properties under prolonged humidity and elevated temperature, comparable to that of the diallyl phthalate materials. J. J. Moyland and P. D. Sullivan, Allied Chemical Corporation (*35*), reported that ease of molding is comparable to that of the usual alkyds, and they look for uses in encapsulated electronic components, terminal strips, switchgears and the like.

Looking for a Job

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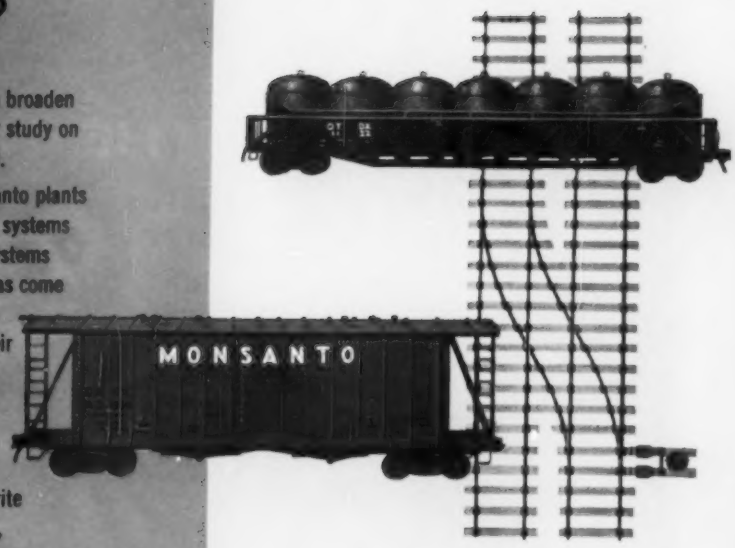
To "Bulk" or not to "Bulk"?

As part of Monsanto's comprehensive program to broaden and facilitate the general use of plastics, a 5 year study on the question of bulk handling was just completed.

This study drew on practical experience in Monsanto plants and in the plants of customers. The popular bulk systems were thoroughly examined and evaluated; new systems were developed and explored. Out of the study has come "A Report to Management on Bulk Handling", a valuable guide to manufacturers in reaching their individual decisions. Out of this study have also come bulk handling services which are shipping millions of pounds of Monsanto Polyethylene, Lustrex styrene, and Opalon vinyl.

If you would like a free copy of the full report, write to Monsanto Chemical Company, Plastics Division, Room 713, Springfield 2, Mass.



MONSANTO RESEARCHER IN **PLASTICS**

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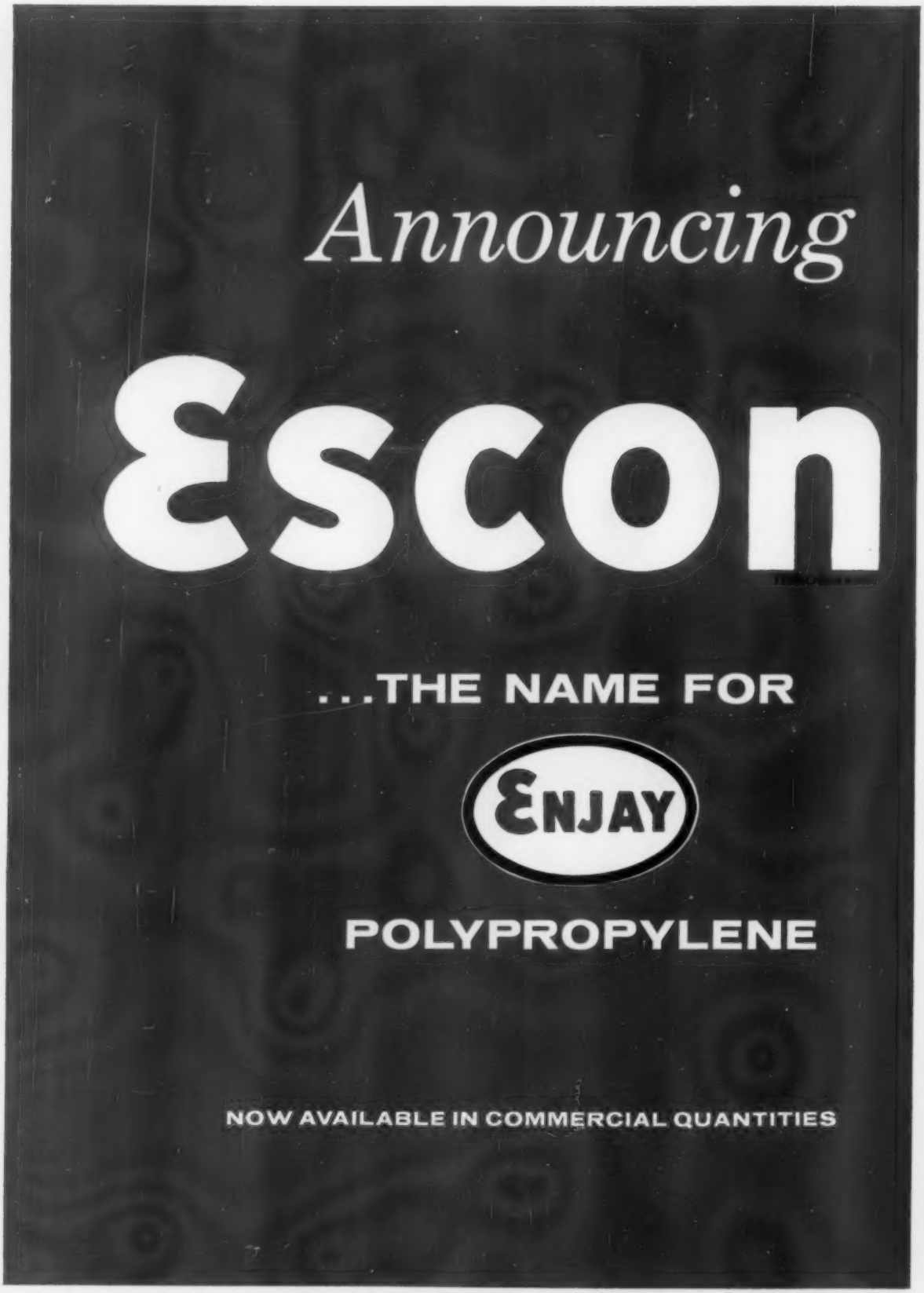
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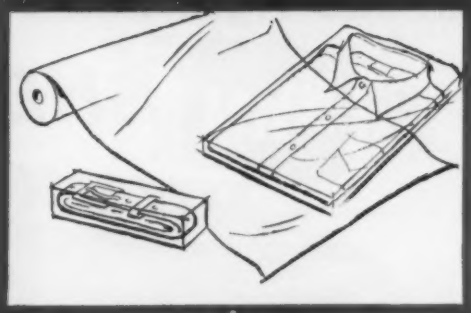
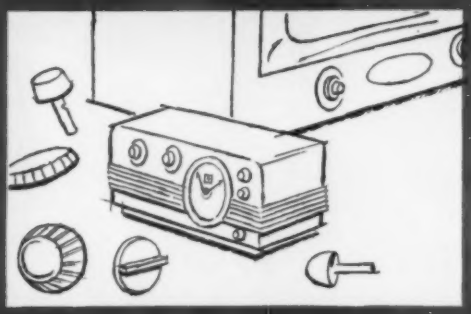
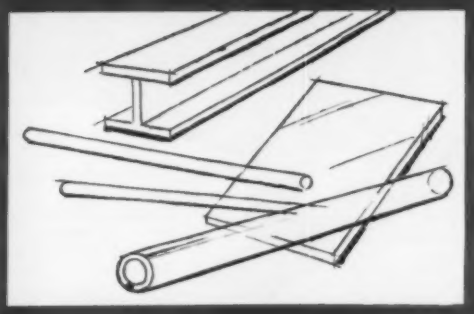


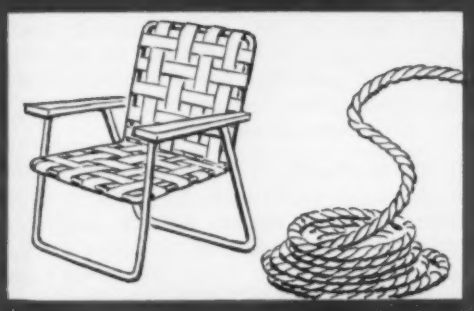
FOR MOLDING – Because of its light weight, Escon yields more pieces per pound. In injection molding, Escon's high strength, plus its unique chemical and abrasion resistance make it suitable for the manufacturing of many consumer products. Escon also allows accurate reproduction of fine patterns and intricate designs with high surface lustre.



FOR EXTRUDING – Escon may be extruded in an almost unlimited range of thicknesses and forms. Its excellent physical and chemical properties make it an ideal plastic for such operations as thermoforming, punching, machining, die cutting and welding. Surface details are accurately reproduced, too. And pigmentation, before or during extrusion, produces bright, even-colored sheet stock.



FOR FIBERS and MONOFILAMENTS – Again, the low density of Escon allows more yards of fiber per pound. Its high tensile strength, good knot strength and resilience, plus its immunity to attack by fungus, moths and marine organisms, make it ideal for ropes and woven fabrics. Ropes of Escon fibers show excellent wet strength, wet flexing durability, and abrasion resistance maintained in temperature range as low as minus 70°F.



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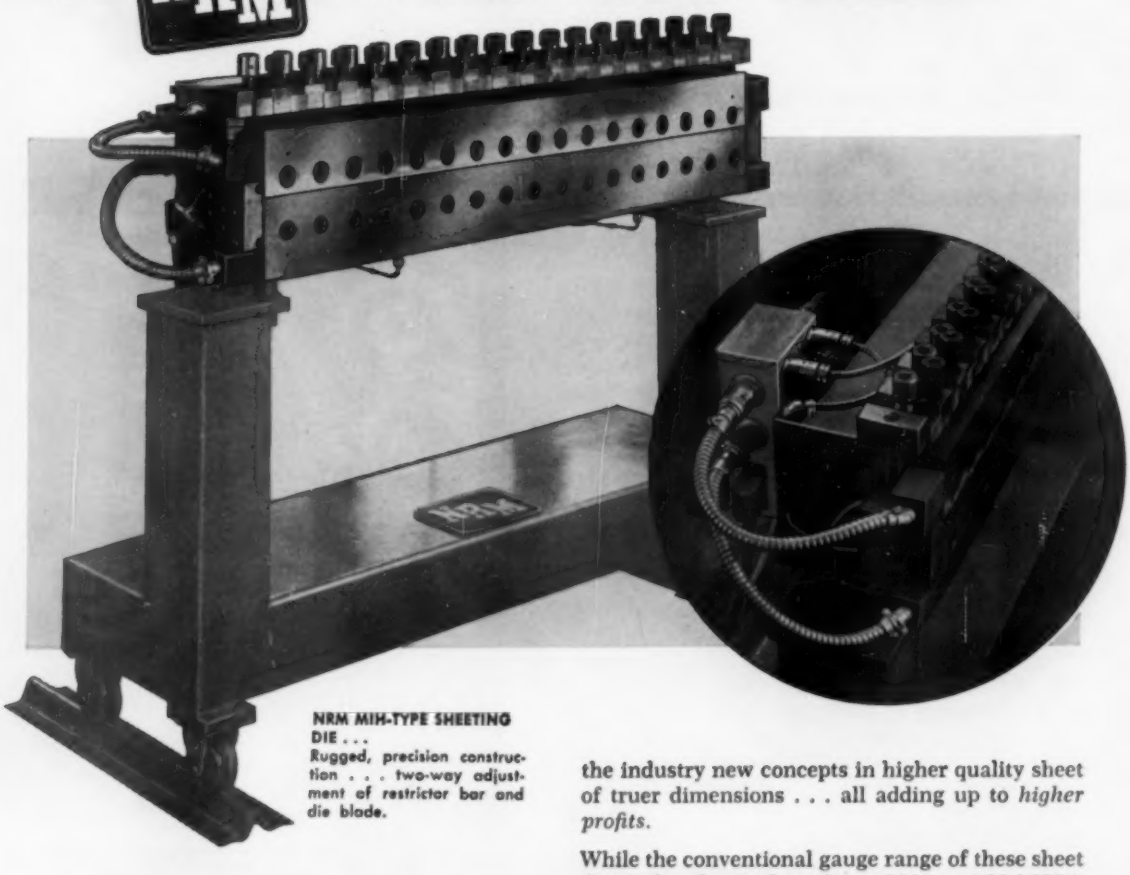

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By: John Badonsky,

Chief Engineer, Extruders Waldron-Hartig Division Midland-Ross Corporation

SPEAKING OF EXTRUSION

Feedscrew Selection Through Simple Rules of Thumb

An engineer in a midwestern extrusion plant once had a feedscrew which was not usable because of its high horsepower requirements. He had the notion that the screw could be modified to extrude at a good production rate. With one modification he succeeded in reducing the horsepower developed, and with a subsequent modification he improved it still further. Ultimately, he achieved an extrusion rate substantially double the amount he would originally have been satisfied with. Each change involved a slight increase in the depth of the metering section. The point here is not that some operators have the ingenuity which may permit them to arrive at a production goal without making a scientific evaluation, but that some relatively simple observations can lead to better screw selection.

The introduction of many varieties of formulations, virgin and rework materials, and many forms of feed particles, has resulted in a complex problem for those individuals who become involved in the selection of feedscrews for slightly unusual applications. Unfortunately, however, it is not always realized by extrusion plant managers that specific operations cannot be thoroughly evaluated without complete information about the operation. It is important to know, for example, whether the product is tubing or sheet, whether the material is virgin or rework, whether the die resistance is likely to be great or small, whether it is a finished product, or whether the operation is an intermediate processing stage.

The extrusion manager has certain "tools" at his disposal with which he may help to develop improved feedscrews. These "tools" consist of some relatively simple observations of the extrusion operation, review of some feedscrew design fundamentals, and the employment of a modest quantity of common sense.

An understanding of the basic relationships of frictional heat, metering flight depth, horsepower, and extrusion quality makes it possible to establish reasonable evaluations of feedscrew performance. This sort of understanding, coupled with the recording of operating data such as indicated cylinder temperature, percentage "on" time of instruments, screw RPM, and motor amperage can very definitely lead to an improvement in feedscrew designs for specific applications.

It is likely that the best designs can be conceived by the combination of all the elements of technique and intelligence which exist for a specific application. This means that the ingenuities of both the practical man in control of production, and the objective man in control of equipment design should be combined in the project of establishing a special feedscrew profile.

The following operating data would be particularly useful to the individual who undertakes the design of an improved feedscrew for a specific application:

1. Actual extrusion melt temperature and the desired temperature.
2. Rate of extrusion (pounds per minute).
3. Actual indicated temperature on each zone and the temperature setting.
4. Number of seconds instrument is "on" and number of seconds "off" for 3 to 5 minute intervals in each zone, include notation specifying which instruments are demanding no heat. These readings, should preferably be taken without cooling being applied, otherwise, it would be necessary to evaluate, (or at least estimate), the amount of heat being extracted.
5. Feedscrew RPM and identify what maximum RPM is available.
6. Amperage drawn by motor, nameplate HP, voltage and full load amperage rating. Record, also, whether motor is AC or DC.
7. Dimensions of feedscrew depths of flight at discharge and feed ends, lengths of metering section and constant root feed section, (if any). Type of transition (tapered root, or "spiral" transition in approximately one turn).

In order to make use of the operating data for evaluating purposes, we must have an understanding of the

fundamental rules of feedscrew design. A listing of some of the fundamental rules follow:

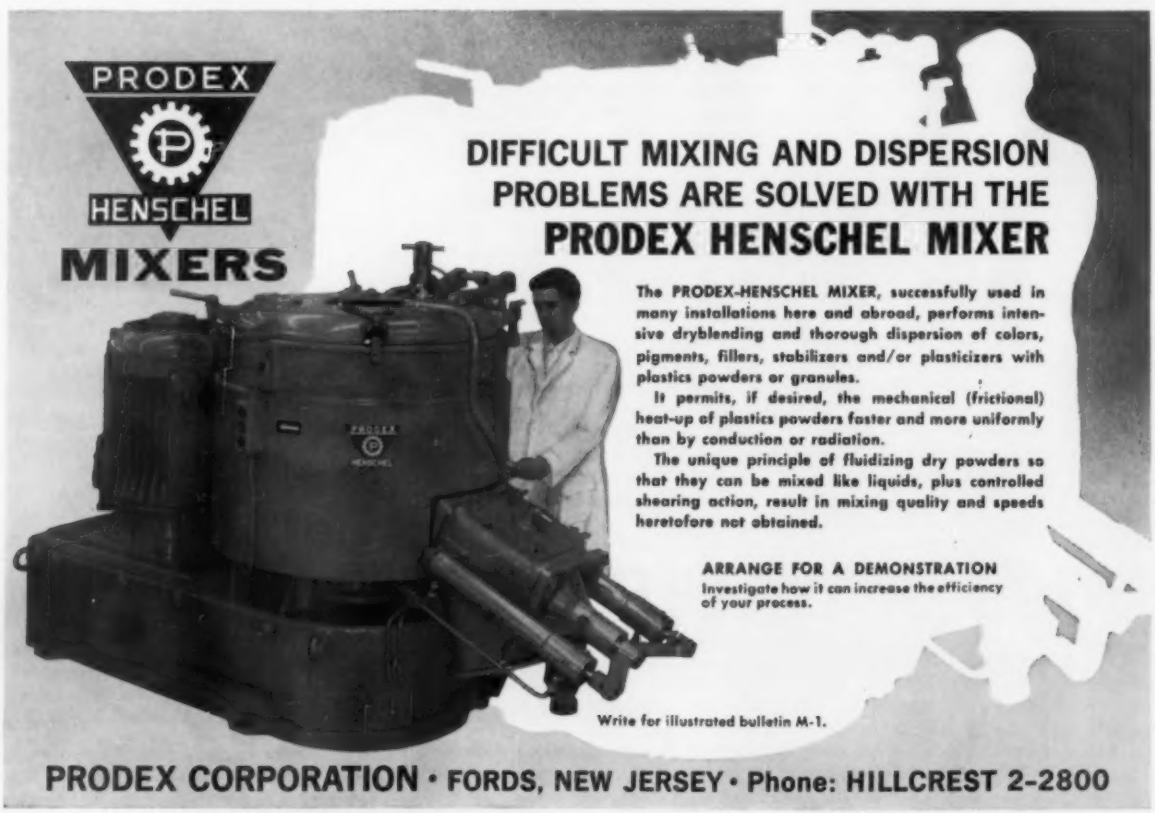
1. Feedscrew must accept feeding material in various forms. Therefore, feed depth should be adequate to handle size of pellet, reground chips, scrap film, or whatever form is encountered. In the case of powder-feed, feedscrew should fit barrel accurately at feed end. Excess wear would affect production.
2. If material being fed is hard, compression should be avoided until material has been softened to a degree. Similarly, if there is tendency to entrap air when small particles are fed into machine, compression should be avoided to permit air to escape.
3. Some taper between the feed and metering sections helps to work material to a greater degree. When taper of root begins immediately at the feed end, considerable friction heat may develop in initial zones.
4. A relatively shallow metering section generally develops uniform flow and uniform quality.
5. The use of water in a screw bore establishes a viscous layer of plastic along the root of the screw. This viscous layer acts to make the screw perform similar to a shallower flighted screw, but flow is very significantly reduced.
   The use of water, however, will often very effectively improve quality, making it possible to operate a feedscrew which is otherwise too deep-flighted.
6. Relative effects of some changes in feed screw profile:
   a. Increase in flight depth of the feed section will generally raise pressure, HP, and output.

A Modernization Program for thermosetting molding equipment — coming next month in the SPE Journal.

   b. Increase in length of a feed section having a constant flight depth will generally have the same effect as increased flight depth, and should also reduce frictional heat in initial zones.
   c. Decrease in flight depth in the metering section generally will raise stock temperature increase mixing action, reduce output and increase HP for a given output.
   d. An increase in length of the metering section will generally have the same effect as a decrease in flight depth in the metering section.
7. Since quality of a given extrusion sometimes falls off at higher speeds, the potential of an extruder may not be completely employed. It is, therefore, quite possible that a screw modification which reduces output per rpm, while increasing quality, can actually be used to produce greater output from the extruder merely by operating at some higher speed. This, of course, assumes that the additional HP is available.

By comparing the information from a data sheet with the fundamentals defined above, the person making an evaluation should be able to identify some pertinent clues which will serve to clear up a few mysteries surrounding a sensitive extrusion operation. Let us take a hypothetical case to illustrate how this can be done.

Material: conventional polyethylene
Form: reground "chips" with small amount of color pigment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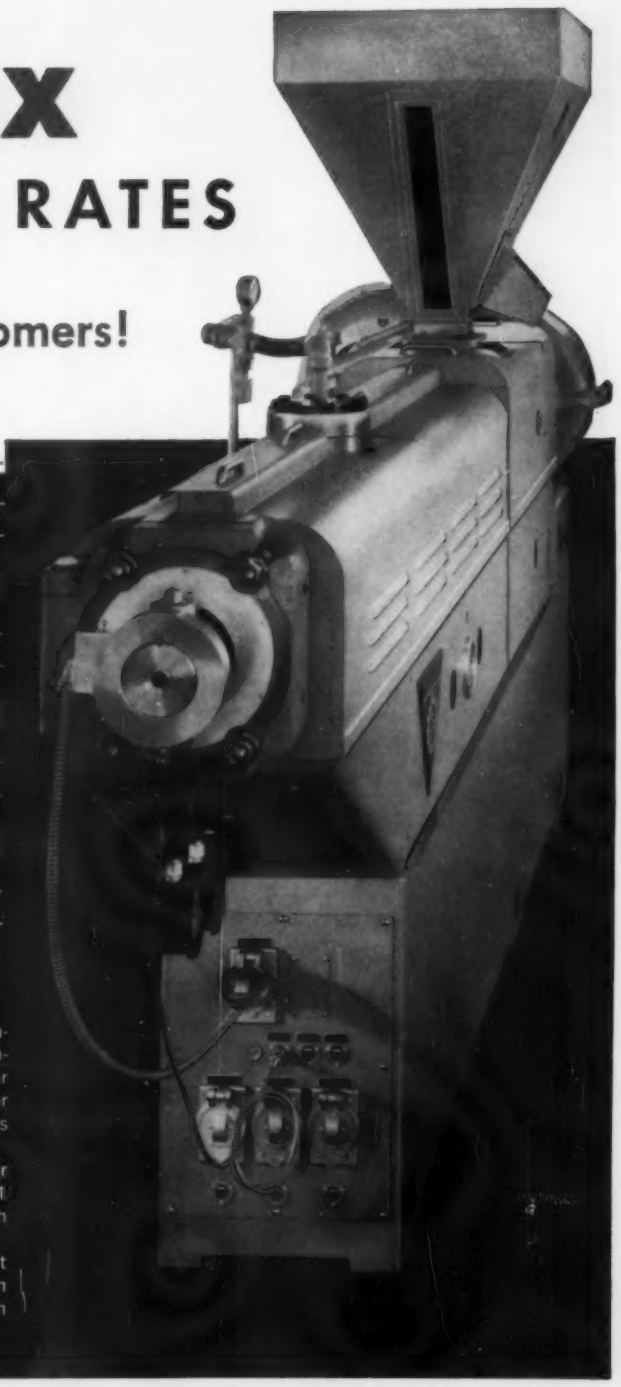

1¾" (10 H.P.)	lbs/hr.
Vinyl tubing from dryblend	120
Linear Polyethylene monofilament	100
Polyethylene blown bottles	110
2½" (20 H.P.)	
ABS Sheet, vented	200
Rigid vinyl pipe from dryblend	170
Polyethylene on cellophane	170
3½" (40 H.P.)	
Vinyl garden hose	480
Polyethylene pipe	380
Roll cast polypropylene film	370
4½" (60 H.P.)	
High impact polystyrene sheet, vented	670
Cellulose butyrate sheet, vented	640
Vinyl coated on wire	690

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111 EIGHTH AVENUE
NEW YORK 11, N. Y.

Product: color-mixed strands for pelletizing
Stock Temperature: 350°F
Cylinder Temps.: (feed) Zone 1, 300°F–Zone 2, 330°F–Zone 3, 360°F
Percentage "on" Time: (feed) Zone 1, 45%–Zone 2, 40%–Zone 3, 35%
Total Wattage each zone: 4 KW
Feedscrew Cooling Water Temperature: 100°F
Actual RPM: 35
Available RPM: 75 maximum
Higher RPM can not be used because quality becomes poor.
Pressure on Breaker Plate: 1100 psi
Screen Pack: 100-80-40 mesh screens.
Extrusion Rate: 50#/hr.
Actual Amperage (Motor): 35
Rated Amperage (Motor): 60
Rated HP (Motor): 15
Feedscrew Dimensions: Diameter: 2-¼
3-turn metering section with 5/32" flight depth
1-turn transition
17-turns constant feed depth at 7/16"
L/D: 21 to 1 on feedscrew

(NOTE: Values are intentionally hypothetical and are not accurately representative of values which would be obtained in practice.)

The evaluation of this hypothetical operation and the suggested modifications are as follows:

1. The use of water cooling on the screw, obviously a requirement for satisfactory mixing, shows that the screw flights at the metering section are too deep.
2. The extruder is demanding a significant amount of heat for the process in all zones, a fact which further demonstrates that the feedscrew is not operating efficiently.
3. Fine screen pack is evidently required to obtain minimum quality.
4. The metering section should be shallower, the transition zone could be tapered for 5 or more turns, the feed depth is satisfactory. Many screw designers would probably be tempted to say that the "standard" polyethylene feedscrew with .093 inch depth is the obvious answer. However, with the realistic attitude of the production man in mind, it should be recognized that this, being a processing operation, quality requirements are likely to be less critical than for a finished product, therefore, high production rates should be considered the ultimate goal. Some value of flight depth between .105 and .120 inches is suggested for this application.
5. It is frequently considered prudent to select a flight depth for a metering section slightly shallower than the estimated optimum. This sort of thinking is justified because it is much easier to modify a screw by removing metal than by adding metal. Therefore, it would seem logical to select the value .105" as the more appropriate one.

Although a considerable number of extrusion people may be inclined to demonstrate their initiative and ingenuity by undertaking an evaluation and modification of an existing feedscrew, it is still considered desirable to rely on the discretion of the design specialists of an equipment manufacturer. Therefore, the submission of operational background data to the manufacturer by the purchaser is suggested as the most practical method of obtaining a quick solution to a specific problem.

—■—

edited by **Bruce H. Maddock**
Union Carbide Plastics Co.

F. W. Reinhart

Chief Plastics Section, National Bureau of Standards

STANDARDS FOR PLASTICS

Who Establishes Plastics Standards?

The purpose of this new feature is to keep readers of the SPE Journal informed about standards for plastics. Standards for Plastics will include methods of test, specifications, nomenclature, recommended practices, codes, and design criteria. Current developments, work underway, and areas where standards are needed will be discussed. The activities of all standardizing bodies will be considered. This initial column consists of a general summary of the activities of the major standardizing bodies and the particular areas in which they are concentrating.

The largest group of plastics standards has been prepared by Committee D-20 on Plastics in the American Society for Testing Materials (ASTM) and issued by that Society. Both, the Society of Plastics Engineers (SPE) and The Society of the Plastics Industry (SPI) are members of Committee D-20 and have strong representation in its work. The National Council of SPE has voted three times in the last 6 years to work with Committee D-20 in the area they cover and not to set up competitive groups. SPI decided some years ago not to issue standards and requested Committee D-20 to process and issue the standards in which SPI was interested as joint standards. There are about 15 of these joint methods at present.

ASTM Committee D-20 has concentrated its efforts on test methods, nomenclature and definitions, specifications for molding compounds, and specifications for standard shapes such as sheets, rods, tubes, foams, films and pipe. Although the scope has covered end items since it was adopted in 1935, Committee D-20 has consistently not undertaken projects to develop specifications for end items such as bath tubs, film for specific uses, garden hose, wall tile, tableware, bottles, weatherstrip, and waterstops. The development of standards for plastics for tooling was recently approved; SPI and the American Society of Tool Engineers are cooperating in this work.

There are about 200 ASTM standards relating to plastics in the September 1958 edition of ASTM Standards on Plastics and about 20 more have been subsequently adopted. About 30 of these are specifications for molding compounds and base materials, about 25 specifications for standard and molded shapes, about 125 test methods, about 25 recommended practices, 5 on definitions and nomenclature, and about 10 on other topics. Several of these are currently being revised and approximately 60 new standards are at various stages of development. About 30 of the ASTM standards relating to plastics have been approved as American Standards by ASA. In the ASTM, all standards are first adopted as tentative and are not advanced to full standard status until after they have been proven to be worthy of this stature by experience.

ASTM Committee D-20 on Plastics has about 600 members of whom about 300 are voting members. There are 21 subcommittees and 111 sections; 16 of these sections are inactive. D-20 is a working committee and as such members must participate by attending meetings or returning letter ballots to maintain their membership. The attendance at each of the three 4-day meetings each year is greater than 200. Subcommittee XVII on Plastic Pipe and Fittings and Section XVIII G on Reinforced Pipe and Fittings are joint groups with SPI. The American Petroleum Institute is also participating in the work of XVIII G. Scopes for all the sections and subcommittees are now being written; a future column will be devoted to this topic. The plastics industry has benefited greatly in respect to the quality and number of standards developed and from savings in the time of personnel involved to do this work from the high degree of cooperation among SPE, SPI and ASTM in the work on standards.

Standards on electrical test methods and plastics used primarily in electrical insulation are developed by ASTM Committee D-9 on Electrical Insulating Materials. The electrical requirements of the specifications issued by ASTM Committee D-20 are supplied by Committe D-9. Committees D-9 and D-20 meet together and there is a high degree of cooperation between them.

Most of the Commercial Standards for plastics issued by the U.S. Department of Commerce have been developed by industry committees sponsored by the SPI with technical assistance from the National Bureau of Standards (NBS). These standards have been recognized for their high level of quality. They are concerned only with end items and some

standard shapes, generally for certain applications. There is some overlapping in the area of standard shapes with ASTM. The SPI industry committees have used ASTM definitions and test methods when suitable ones are available. The methods of tests developed by the SPI committees are submitted to ASTM for further refinement, improvement, and issuance as joint SPI-ASTM methods. The Commercial Standards for plastics currently being developed and revised numbers about 35. About 20 have been issued.

The preparation and issuance of Federal Test Method Standards and Specifications is the responsibility of the General Services Administration (GSA). They are prepared solely for governmental procurement purposes. Most of the Federal Specifications for plastics are prepared by military agencies for GSA. NBS has accepted responsibility from GSA for preparation of the revision of Federal Specification L-P-406 on plastic test methods into Federal Test Method Standard 406. Many of the Federal Standards Test Method and Specifications for plastics are coördinated closely with co-existent ASTM Standards.

Military Standards are prepared and issued by the Department of Defense (DOD) for procurement purposes. The standards are prepared by various agencies in DOD and include specifications for plastic end items and some materials.

Technical Committee 61 on Plastics of the International Organization for Standardization (ISO/TC61) has completed their work on 28 test methods, are working on about 10 more test methods, and have work underway on nomenclature and definitions. Work on materials specifications was initiated in 1959; their initial effort will be confined to selection of properties to be specified and test methods for their measurement. The test methods are based in many cases on ASTM Standards. ASA holds the Secretariat for ISO/TC61. The work on International Standards in ISO/TC61 on Plastics is conducted in Committee D-20 for the American Standards Association (ASA); SPE and SPI are represented in this work and have made significant contributions to the work of this subcommittee, known as the USA National Committee for ISO/TC61.

The American Standards Association (ASA) is an association of societies which are concerned with the development of standards. Their principal effort in plastics has been investigating the status of ASTM Standards to determine whether or not they meet the requirements of national concensus so that they can be approved as American Standards. ASA Sectional Committees B 31 and B 72 are working on standards for plastic pipe and B 16 on fittings.

Standards for plastics like all materials standards, are growth documents. As our knowledge of science and engineering increases, as new testing devices and materials are developed, and as current materials are modified, standards now in use will need to be revised and new standards need to be developed. Materials standards might be considered as "living documents" that grow because of their nature. If they are nurtured by giving them a continuous supply of the food of science and engineering, they are healthy and useful. If they are not nurtured by giving them the proper food continuously, their health suffers and eventually they become weak and useless.

—■—

edited by **Frank W. Reinhart**
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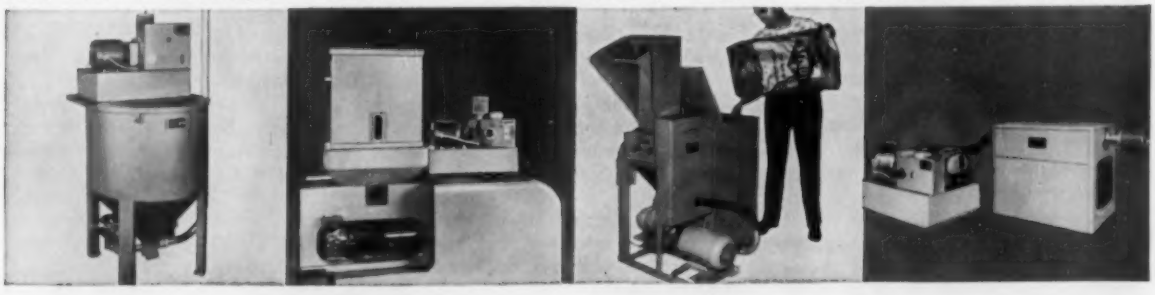

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U.S.I. POLYETHYLENE NEWS

A series for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

FEBRUARY, 1960 — U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corporation — 99 Park Ave., N. Y. 16, N. Y.

Packaging Notes

Skin suspension packaging with polyethylene film is being used with great success for shipping pottery and ceramic products.

The packages consist of a low density polyethylene skin suspension on a polyethylene-coated corrugated board. The coated board is perforated to allow a vacuum to be drawn through it. Then, products are placed on the board and 6-10 mil polyethylene film is heated, vacuum formed around the products, and heat sealed to the board. The completed unit is packaged in a corrugated container for shipment.

This packaging technique has cut gross shipping weight by 40%, and in-transit breakage has been reduced by more than 60%.

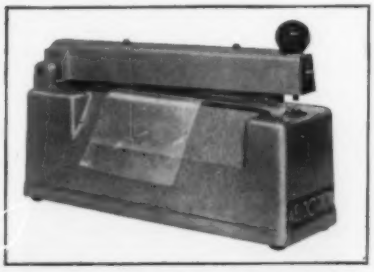
Now... polyethylene packaging for people!

A rectangular-shaped tent of polyethylene film is currently being marketed for use at football games and other outdoor sporting events. The tent is opaque except for a clear polyethylene viewing window. The tent keeps heat in — rain and snow out.

Polyethylene film packaging for carbon-steel tubes has proved to be economical for a New Jersey refinery.

Polyethylene film is wrapped around a cluster of tubes and taped securely closed. Wrapping with polyethylene in this way protects the tubes from rust and corrosion during storage.

Another advantage: packaging cost is said to be one-eighth that of the military-style moth balling the company formerly used.



A polyethylene bag sealer for small lots and laboratory use is now being marketed by a New Jersey Company.

The new compact polyethylene heat sealer is only 4 inches wide and 12½ inches long. It is portable and may be plugged into a standard 110 to 120 A-C outlet. The sealer will produce seals up to eight inches long. Sealing time is one-half to two seconds, according to the thickness of the film.

Improved Film-Clarity Meter Designed by U.S.I. Chemist

New Instrument Eliminates Human Error in Testing Clarity

A research chemist at U.S.I. has designed in conjunction with A.S.T.M. a new light transmittance meter which eliminates human error in testing clarity of polyethylene film. The instrument determines the relative amount of light transmitted through any film specimen at essentially a zero angle of scatter.

This new low-angle light transmittance meter was developed at the Polymer Service Laboratories of U. S. I.

The new meter is designed to replace the optical bench test . . . a method which depended on the operator's eye-sight. With the new meter, test results are recorded automatically, without relying on the judgment of the operator.

Operation of the Meter

Basically, the meter consists of a light source which is concentrated through a sample of film onto a light-sensitive cell. The cell is attached to a galvanometer which measures the amount of light passing through the sample to be analyzed.

Swatches of polyethylene film 1.5 mils thick were used as standard gauge samples by U.S.I. Care was used in handling the samples, since fingerprints on the film could cause variations as much as 10% in light transmittance.

Meters of this type are currently being evaluated by other laboratories in an A.S.T.M. round robin test.

New Polyethylene Packager Cuts Labor Costs by 50%

A west coast manufacturer recently announced a low-cost packaging machine which fills, closes and produces a finished bag in a single operation. It is designed to use bulk rolls of polyethylene film, and packages items which range in size from pencils to shirts.

The machine is said to cut packaging labor costs up to 50% through speed and efficiency of operation. The unit eliminates time-consuming hand loading of pre-manufactured bags. It reportedly eliminates set-up time, since no adjustment is necessary when changing from large to small size bags.

It is also reported that the machine can be operated by personnel who have no previous training or experience in packaging.

Now... Disposable Boots of Clear Polyethylene!

Low in cost, but high in protection are features claimed for newly introduced clear polyethylene boots. These disposable boots are easily pulled over regular shoes, and can be worn open at the top or closed with a rubber band.

Uses suggested for these inexpensive boots include biological and atomic laboratories where control of contaminated elements is vital.

The manufacturer currently packages his product in rolls of 50 and 100, and says average cost is less than 14¢ per pair. The boots are watertight, and last for several hours before wearing through, it is claimed.

Polyethylene Pipe Solves Difficult Tamping Job

Polyethylene pipe has been put to an interesting use in blasting operations for a new Potomac River water treatment plant near Washington, D. C.

A total of 62 holes were drilled to prepare a 110 ft. high cliff for blasting. Fourteen of these holes were from 35 to 96 feet deep and drilled at an angle of 32°. Since the density of the rock formation varied, there was a chance that the bore holes would swing out of line by several feet. Of major concern was the problem of loading and tamping blasting charges to the required depth in the crooked holes. Conventional, non-flexible, metal rods quite obviously would not do the job.

The blasting contractor solved the problem by using 1½" intermediate density hollow polyethylene water pipe. The highly flexible polyethylene tamping "pole" was made up of several sections of pipe.

It easily took the bends in the holes and was used successfully to tamp all required blasting caps and powdered charges in place.

DO YOU HAVE a new polyethylene packaging development you'd like the industry to know about? Make it routine to send your information on new developments to U.S.I. POLYETHYLENE NEWS.

Address the Editor,
U.S.I. POLYETHYLENE NEWS, U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corp., 99 Park Avenue, New York 16, N.Y.

exceptional moisture and grease resistance

POLYETHYLENE-COATED KRAFT OPENS UP NEW OPPORTUNITIES FOR CORRUGATED BOARD

Polyethylene-coated corrugated board — produced on conventional corrugating equipment — is extending the usefulness of corrugated into many new packaging applications.

This unique container board has exceptional moisture and grease resistance and a glossy, non-abrasive liner surface that will not scratch or mar package contents.

Extruders who produce polyethylene-coated kraft liner board can get these extra advantages by using U.S.I. PETROTHENE® polyethylene resins:

HIGH PRODUCTION RATES—PETROTHENE resins have good drawdown properties, permit extrusion at high speeds.

EXCELLENT ADHESION — with minimum hot melt oxidation.

NO ODOR — an important consideration in many packaging applications.

Contact U.S.I. for information on PETROTHENE resins especially suited for coating kraft liner board.

Packagers are investigating polyethylene-coated corrugated board for applications like these:

Bulk shipment of meat, where moisture and grease-proof interiors reduce weight loss of the meat and keep moisture from weakening the carton.

Shipment of furniture and other hard goods, where abrasion damage from the container has been a problem.

Bulk bakery and confectionery shipments, where absence of grease-wickage makes containers suitable for reuse as point-of-sale displays.

In concrete construction forms, where the polyethylene coating acts as a release agent.

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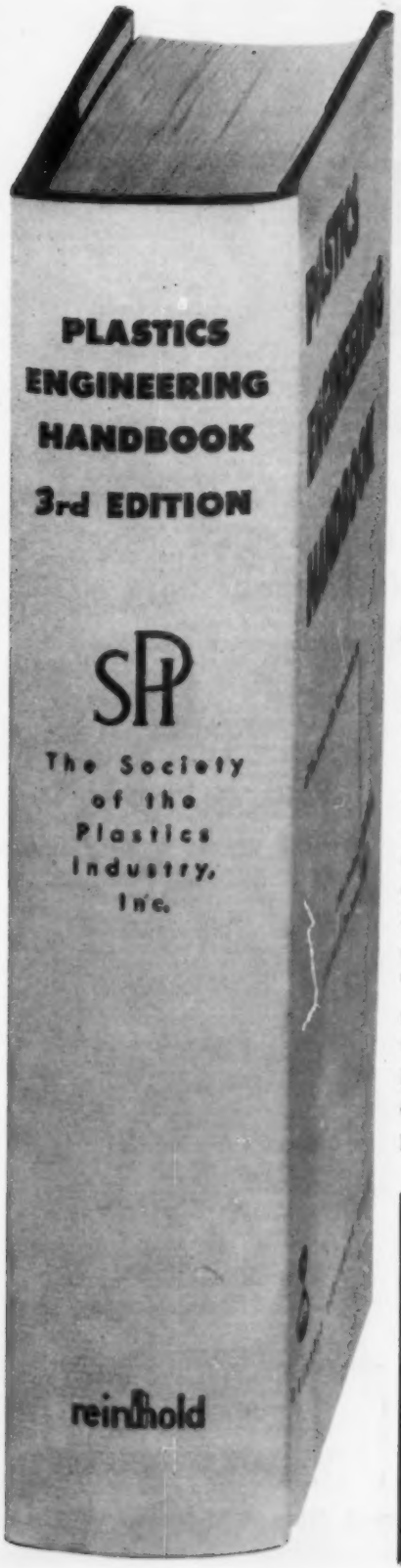

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See other side for Table of Contents

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- Combination of Injection and Compression
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- Molding of Urea-Formaldehyde and Melamine-Formaldehyde Compounds
- Molding of General-Purpose Polyester Molding Compounds
- Molding of Alkyd Materials
- Molding of Thermoplastic Materials
- Molding of Fluorocarbons
- Advantages of Compression Molding
- Limitations of Compression Molding
- Details of Procedure for Compression Molding
- Types of Compression Molds
- Machinery and Equipment
- Automatic Compression Molding

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- Description of Process
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- Advantages of Transfer Molding
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- Materials Used
- Theoretical and Design Considerations

5 INJECTION OF THERMOSETTING MATERIALS

6 COLD MOLDING
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- Advantages of Cold-Molded Articles

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- Mold Lubricants
- Characteristics of Injection-Molding Compounds
- Details of Injection-Molding Machines
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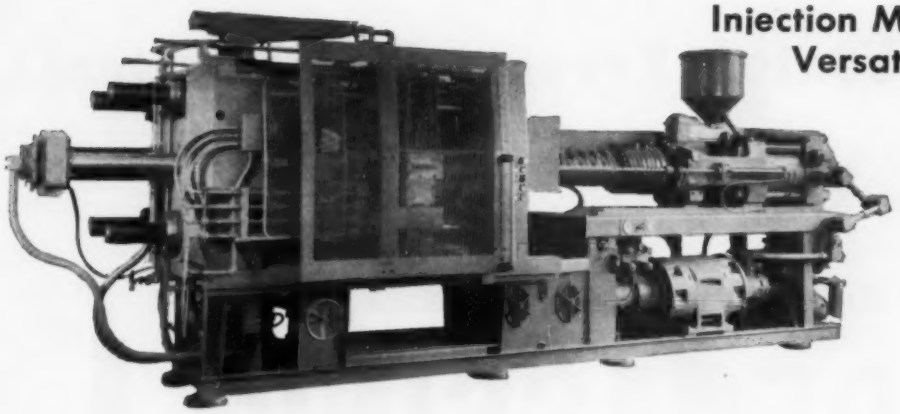

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MOLDING CYCLES

Mold Design For Improved Cycling

Six new ideas for improving injection mold cycle time

Injection molding machine cycle time is one of the most important economic factors in the cost of a finished plastic part. Generally, the more parts per hour coming from a machine, the lower the cost of each part. Improved cycling is a natural aim in any plastic injection molding operation. Considerable attention and effort have been focused on improving molding cycles through molding machine design refinements and innovations. Attention and effort, also, have gone into mold design to speed up machine cycling. Some of the newest refinements in hot runner and conventional mold design to further improve cycle time have been concentrated in the areas of, one, isolating hot runner heat from the cavity and, two, increasing the amount and effectiveness of cooling in certain cores and cavities.

Three hot nozzle insulation techniques and three new mold cooling techniques which offer real promise for cycle improvement are presented here.

Isolation of Hot Runner Heat From the Cavity

Ideally in a hot runner mold, it is desirable to adjust the temperatures in the gate area so that neither freezing nor drooling occurs. The degree of temperature control required is difficult to achieve, particularly when the tip of the nozzle is in direct contact with the cavity insert. Three solutions have been studied.

Semi-Insulated Nozzle

The semi-insulated nozzle shown in *Figure 1* helps solve the temperature problem by not making contact at the gate area. The void around the nozzle tip fills with plastic during the first shot. This plastic remains to insulate the hot nozzle from the cold metal. Contact is removed from the gate, thus permitting the nozzle tip to remain warm and the adjacent cavity metal to remain cool. This design allows lateral movement of the hot runner plate from the center line without causing serious misalignment of the nozzle tip and gate. It avoids the problem encountered in other hot runner mold designs where the actual expansion of the hot runner block differs from the calculated value.

The thickness of the plastic around the sides of the nozzle is not too critical; a 1/16″ wall has proved satisfactory. At the tip, however, plastic thickness should be in the range of from 0.015″ to 0.030″, depending on the gate dimensions. Where many cavities are involved and the hot runner plate may tend to warp out of plane because of its size, leakage and improper nozzle seating can be a considerable problem. "Floating" of the nozzle in the runner plate is an important design feature which allows pressurized contact of the nozzle seat with the cavity metal. The nozzle is free to move downward as shown in *Figure 1* when acted upon by plastic pressure on the top of the nozzle. Piston rings are used to seal the plastic. On smaller molds where warping should not be a serious problem, the nozzles have been threaded into the hot runner blocks. Both the floating and threaded type nozzles have been used successfully on production molds, primarily by West Coast molders. Best results, so far, have been obtained with beryllium-copper nozzles and steel cavities.

A thread bobbin mold, shown in *Figure 2*, incorporates the plastic insulated nozzle in the hot runner system. This 24 cavity mold could only be made in two rows due to the need of opening the cavity plates for ejection. The cavity plate movement, as shown in the right hand portion of the figure, is unusual, since the upper and lower plates of each row are con-

This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

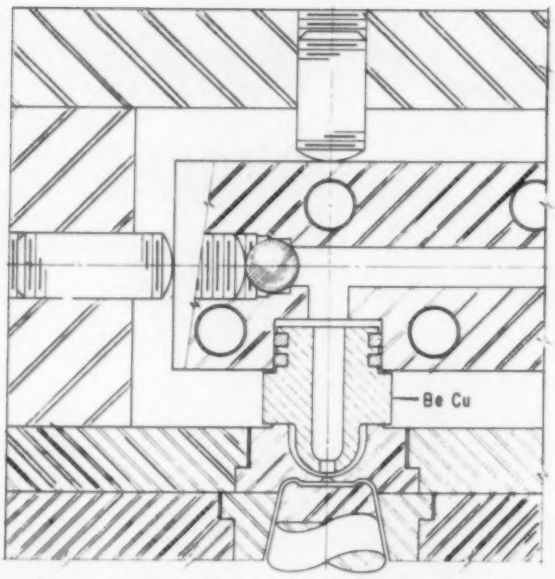


Figure 1. Hot runner mold floating nozzle type.

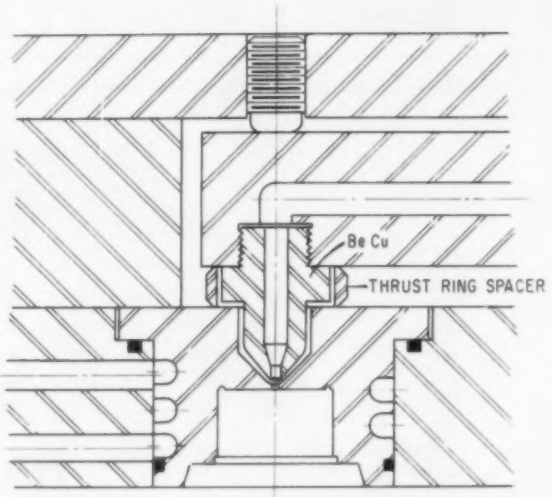


Figure 3. Hot runner mold insulated nozzle type.

nected, requiring only two sets of leader pins to accomplish the motion.

Fully Insulated Nozzle

Often the part appearance calls for a less obvious gate than that shown in *Figure 1*. To make a gate barely visible, the diameter must be kept very small (0.015" to 0.025"). In addition, the gate land should not be tapered as in *Figure 1*. Since the gate land must be kept short to prevent freezing, the cavity metal separating the nozzle side from the cavity side would become quite thin if a spherically shaped nozzle were used. *Figure 3* shows a conical shaped nozzle which leaves more metal on the top of the cavity, making a short land gate possible. The tip of the nozzle in this design is thinner and less heat is available at the very end. To further insulate the nozzle, a steel thrust ring spacer was placed around the nozzle base. This allows the nozzle to be completely suspended in plastic and prevents it from making any contact with the cavity.

Again, best results were obtained with beryllium-copper nozzles and steel cavities. With beryllium cavities, larger gates were required to prevent freezing because of this material's higher heat transfer.

Internally Heated Nozzle

The internally heated nozzle offered by Injection Control Corporation, 677 So. Eaton, Birmingham, Michigan offers excellent temperature control at the nozzle tip. We believe, therefore, it should seriously be considered for

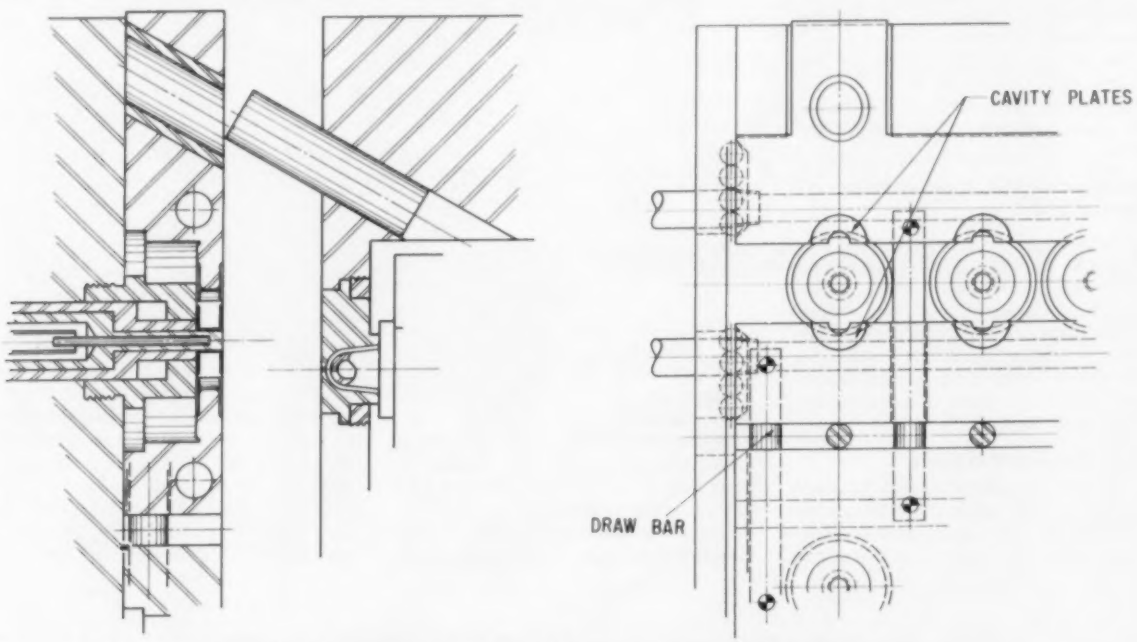


Figure 2. Mold for thread bobbin, with right hand drawing showing cavity plate movement.

hot runner molds. *Figure 4.* By modifying the nozzle feed entrance, the nozzle can be shortened, allowing space for longer cavities.

The torpedo heater is regulated by a variable transformer giving the operator a wide range of temperature control. Plastic flow occurs most rapidly around the heated torpedo and the rate falls off near the outer cool walls. Thus, in effect, the plastic on the outside of the channels insulates the cold outer wall of the nozzle from the heated plastic and torpedo. The heat from the torpedo tip prevents the gate from freezing. The insulation allows the metal surrounding the gate to run cooler and not make the "hot mark" defect commonly seen in many hot runner molds.

Rather than using a massive hot runner block for a small number of cavities, the use of internally heated hot runners may prove beneficial. This employs essentially the same principle as used in the internally heated nozzle. Now for the first time it may not be necessary to use a "hot rod" polymer to achieve fast cycling provided the hot rods are in the nozzle and runners.

Improvements in Cooling

Thus far, attention has been directed to the hot end of the hot runner mold. Cooling the cavities and cores deserves equal, if not more, attention. Many times the machine and mold combination is very adequate for supplying the heating needs but the molding cycle is restricted by inadequate cooling. Three examples of techniques for improving cooling are given.

Furnace Brazing to Include Cooling Lines

In certain shapes, the common method of drilling would be impractical and costly—in some cases impossible. One way to locate the cooling lines where they are needed is to use furnace brazed cavities and cores. In this method a cavity is made having an inner and outer section with the cooling lines lathed or milled and the parts brazed together during heat treatment. Circular and flat cavities such as those shown in *Figure 5* lend themselves very easily to this method. Thus, the cooling lines can follow the contour of the cavity (or core), be closer to the cavity surface, and provide more uniform heat removal.

Another feature of brazing is the brazing temperature can be the same as the heat treating temperature for hardening and, therefore, both can be accomplished at the same time. This means, of course, the cavity must be finished to the polishing dimensions prior to brazing and heat treating. A good selection of steels is available to the mold builder but those having different hardening temperatures may require a different brazing material, as shown in *Table 1.*

The success of coring by furnace brazing depends on careful attention to a number of factors. One important consideration is the wall thickness or mass relation of both pieces to be joined. The heating and cooling cycle for dissimilar masses of metal may cause high enough stresses to produce cracks. Selecting the proper brazing material to correspond with the type of steel being used is important also. Other items include smoothness of finish needed on the brazing surfaces; design of locating fixture to hold the alignment between pieces being brazed; flatness and clearances of the brazed surfaces and limits of the atmospherically controlled furnace. Furnace brazing is a relatively new process and should be considered still in the development stage. It requires

TABLE 1.

Heat Treating Temperature	AISI Code No.	Brazing Material	Hardness Rockwell "C"
1500°F to 1600°F	A4, A5, A6	Silver Solder	54 to 60
1600°F to 1900°F	D1 thru D5	Copper Braze plus 8% Sn	54 to 61

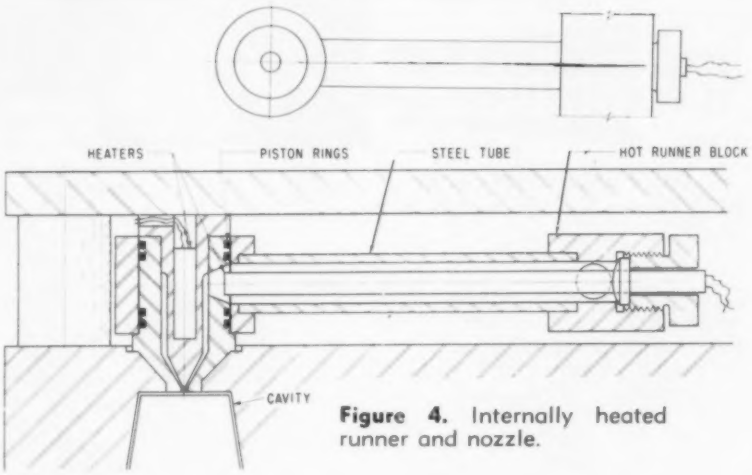


Figure 4. Internally heated runner and nozzle.

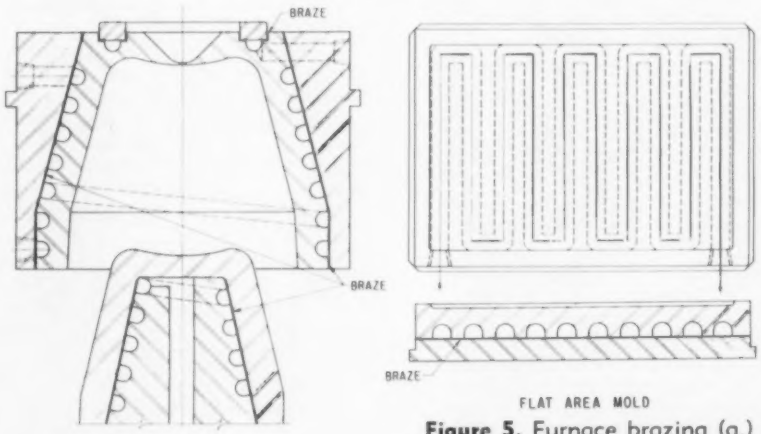
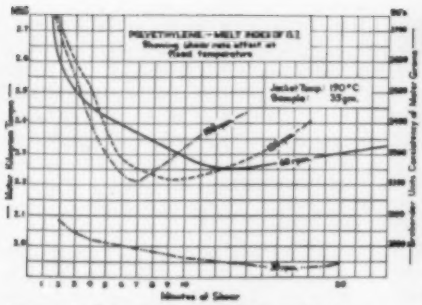


Figure 5. Furnace brazing (a.) Cylindrical mold. (b.) Flat area mold (c.).



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close liaison with the heat treating or brazing companies. The better cooling that results from this technique is, we believe, well worth the extra effort, and slight additional expense above that normally required for regular hardening heat treatments.

Cooling Collapsible Cores

Many multicavity molds are designed to produce threaded closures that do not have good cooling inside the small cores since they must be rotated to remove the part. Improved cooling means improved cycling and our next slide *Figure 6* shows a collapsible core that readily accepts a bubbler cooling system. The cooling channels consist of a center tube and an outer water return passageway. The hoses connecting the water to each of the cores require freedom of movement since they ride back and forth with the wedge.

The withdrawal action of the center section moves each side of the core just enough to clear the threads. The part is designed to stay on the center wedge section of the core, we released and an air blast moves the closure off of the collapsed core. Although we are only cooling the center wedge section of the core, we feel this is an improvement over merely cooling the core retainer plate.

High Conductivity Rods For Core Cooling

Another cooling problem is encountered in small cores where sufficient room at the tip to locate a bubbler is not available. An example is shown in *Figure 2* where the heat transfer path is provided by inserting a beryllium-copper rod. The back end of the rod is centered in the bubbler.

Summary

Six ideas for improving injection molding cycle time have been presented—a few of them have been used commercially, several are under study in Dow Plastics Technical Service laboratories, and the remainder are design concepts on paper only. It is hoped that these ideas will stimulate even newer concepts and refinements in mold design which contribute to improved cycle economics.

Notice

The information in this article is presented in good faith, but no warranty is given, nor is freedom from any patent to be inferred.

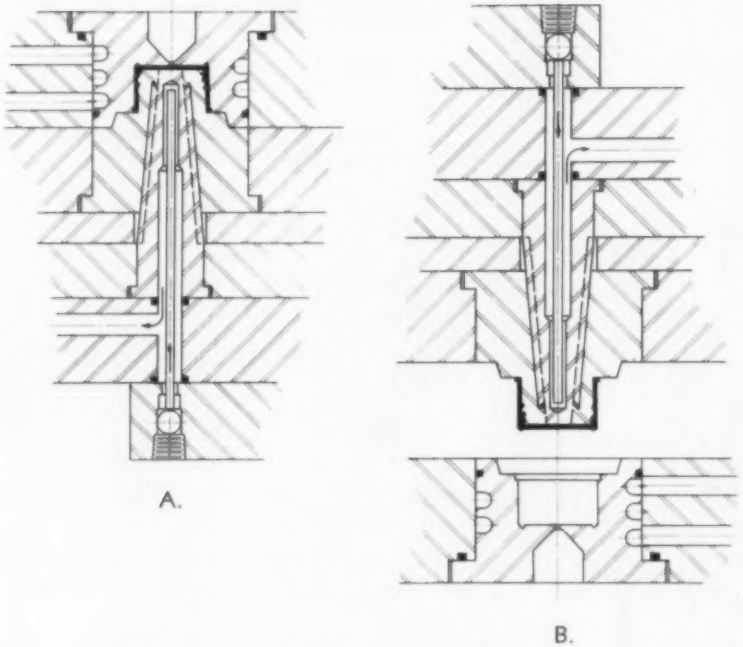


Figure 6. Closure mold with collapsible core (a.) Mold closed (b.) Mold open.

—■—

edited by **L. Paggi,**
E. I. du Pont de Nemours & Co., Inc.

E. P. Weaver*

Atlantic Marine Industries, Inc., Pemberton, New Jersey

MOLDMAKING

Large Reinforced Plastic Molds

The "secret" in the manufacture of a successful large mold lies in the thought and planning that precedes its manufacture. There is no substitute for and no reason to accept less than the best tool suitable for the job. This paper will describe those factors which we believe are necessary and outline certain methods which would be of assistance in mold making.

Steps Involved

Before production molds can be made certain elements must be present and a sequence of operations followed. For our discussion we will assume that the elements already present are:

1. An acceptable design.
2. A Tested prototype.
3. An engineer familiar with reinforced plastics.

In the instance where several molds are required, the following sequence is recommended.

1. Pattern
2. Master mold
3. Mold master from which the production molds are made.

There are conditions under which variations are desirable. One such set of conditions might involve the tested prototype being used for the pattern and the master mold being used for the manufacture of production parts. Here the steps involved have been reduced to a minimum with a resultant cost savings which could be regarded as substantial. Such a reduction, however, should not be considered without a thorough evaluation of the individual condition.

Requirements for Planning and Engineering

Before any of the basic steps are begun, several questions should be answered to first determine whether all of the basic steps are to be involved and second to determine the best route in each step. Usually this is done in the estimating stage either for a customer's quotation or as a presentation to your own management where proprietary items are involved. Naturally, the more detailed your study can be, the closer your estimate will represent actual conditions of manufacture. In determining what steps are to be taken, the questions to be answered should be of the type:

1. Will one mold suffice to produce the required units in the given time?
2. Had a full scale model been required for approval and testing, can it be used as a pattern and can it be used for more than one mold?

Detailing these questions will involve such considerations in making the mold as:

1. What is the best approach from the pattern making point of view?
2. What part requirements will determine how the mold is to be made?
3. Considering production, can molding operations be simplified or can some assembly operations be eliminated?
4. What is best from strength and bracing standpoint?

Most molds will be a result of the best overall compromise and a clearer picture can be had if as many fine points as are applicable to the condition can be covered as exemplified below.

1. For Pattern Making
   a. Should the mold be made in one piece?
   b. Male or Female?
   c. Will only a half pattern be required due to symmetry or other reasons?
   d. Has full attention been given to such as: run off required, sufficient radii, undercuts, part thickness, clearances and tolerances?
   e. What are finish requirements?
2. Part Requirements
   a. Must the part be one piece?
   b. Where are seams or joints least objectionable or where can they be used to advantage?
   c. Can the mold be made in several parts to suit molding or assembly convenience?
   d. Is the part to be refinished or used as molded?
3. Production Requirements
   a. Would it be of advantage to use the mold itself as a jig?
   b. Can a simple jig release a mold to production?
   c. Can some assembly or finishing operations be eliminated by making a one piece molding or by splitting the part at the right place without excessive detriment to the molding operations?
   d. Should the molds be stationary or movable?
   e. Can staging or platforms be eliminated by a split mold?
   f. Would it be of advantage to eliminate costly jigs and fixtures at the price of a more expensive molding operation?
   g. Can standard width materials be used to best advantage?
   h. Are all portions of the mold easily accessible to suit the hand layup method?

This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

* *Now with Naugatuck Chemical Co.*

Once these questions have been answered and committed to paper, a good picture of what is to be done is ready, the operations required are known and a close cost evaluation may be made, since during your evaluation the materials of construction, mold thickness, strength, amount of bracing and so on will have been covered. Consequently, the amount of man hours, materials and special equipment can be specified.

Check Lists and Schedules

Actually, at this point, only the ground work has been laid for the successful large mold. All your thinking, calculating and planning will be to no avail if each stage of the operation is not checked. Confer with the persons who are to be responsible for each major step in the operation either singly or together and go over exactly what is to be done, how it is to be done, who will do it, request suggestions then develop a check list and schedule of operations coupled with a realistic time table. Once these are established, stay with them. Make haste slowly at first and provide yourself with a list of critical phases which you personally will oversee, direct or approve. To illustrate, a generalized molding check list and schedule is given in Appendix "A".

Pitfalls

The check list above can also act as insurance against pitfalls or mistakes which may prevent the use of the mold in production or that may require costly rework and refinishing operations on the molds, parts or both. Some of the more prevalent errors and their causes are:

1. Rippled or uneven appearance—Pattern not splined or sanded sufficiently or properly.
2. Rough surface, wood grain, etc.—Pattern not polished sufficiently or surface prepared properly. Parting film or agent not properly applied, dust or dirt on surface before the overlay is sprayed.
3. Regular lines at periodic intervals—Station marks in the pattern not removed or bracing transfer due to wood bracing lying hard against the outside of the mold.
4. Deformation—Point or line stresses—Excessive weight borne by one brace and not transferred to a large area can cause the laminate to yield. Insufficient cure and resulting low strength can also contribute to this as well as too thin a mold or improper bracing.
5. Cracks in the overlay—Too rigid an overlay material, too thick an overlay, impact stresses during usage, excessive deformation during usage. i.e.—Use of wedges to remove part.
6. Pattern transfer—Application of first plys of glass too soon after spraying overlay. Insufficient "back up" laminate between overlay and woven roving.
7. Blisters or break through of overlay.— Voids during manufacture of the mold. Resin gelled too quickly to prevent proper working out of air. Resin not sufficiently thixotropic allowing too much run off. High exotherm causing "blowing" of resin.
8. Warpage—Too many layers or plys applied at one time or too soon after each other causing strains to be set up due to high exotherm. Improper or insufficient post cure.

Trouble shooting in large mold making should begin before the mold is made by anticipation. We prefer to use a high impact resistant overlay with a high heat distortion point resin. Our back up laminate usually consists of three to five plys of a fine woven material like 1000 cloth followed by additional plies of 1-½ oz mat and 24 oz roving to add strength at moderate cost. The mat is also used as a buffer against pattern transfer and mold thickness is normally ⅜". One ply per day is applied with a catalyst system arranged to give lower exotherm and reduce shrinkage. With such a system proper aging on the pattern is a requisite, two or three days in the sun or an oven post cure for a similar period at 110° or 120°F is usually sufficient. (A good reference is a paper "VIBRIN MOLD TOOLING FABRICATION" by W. K. Fischer). Many variations on this general set up are possible and desirable depending upon conditions. However, take the material limitations into account and act accordingly.

—■—

Appendix A

MOLDING CHECK LIST

1. Materials of Construction and total amounts

a. Parting Agent
b. Overlay, catalyst or hardener, promoter, diluents and fillers.
c. Resin type, catalyst or hardener, promoter, diluents and fillers.
d. Reinforcements, type size and finish.
e. Bracing and framing materials

2. Reinforcement Preparation

a. Provide cutting list and patterns where necessary.
b. Stack cut patterns on hand trucks or skids after coding so that they may be removed in order of layup.

3. Method of Layup

a. Application of parting agent
  (1) Number of coats.
  (2) How it is to be applied
b. Application of Overlay
  (1) Number of applications and time between
  (2) Formula for each application
  (3) Time to be allowed before layup is begun
c. Layup
  (1) Layup list showing location of patterns coding, etc. Cutting list can be used.
  (2) List resin formulations. Use master batches wherever possible.
  (3) Give amount of resin mix required per ply or pattern depending on method of application.
  (4) Where required, provide a graph or table of catalyst per pound of resin mix versus temperature to give required gel time.

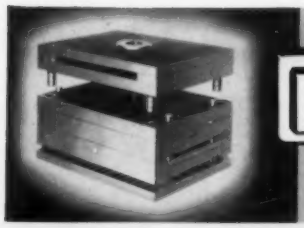
4. Bracing

a. Provide diagram of exact location and type of bracing.
b. Describe method of attachment to mold.
c. Have bracing units prefabricated and preassembled wherever possible.

In each of the above, the following can also be listed.

1. *Equipment required in type and number.*
2. *Men required and time allowed for each phase.*
3. *Defects or things to watch for and corrective action.*

edited by **Ernest J. Csaszar,** *Newark Die Company*



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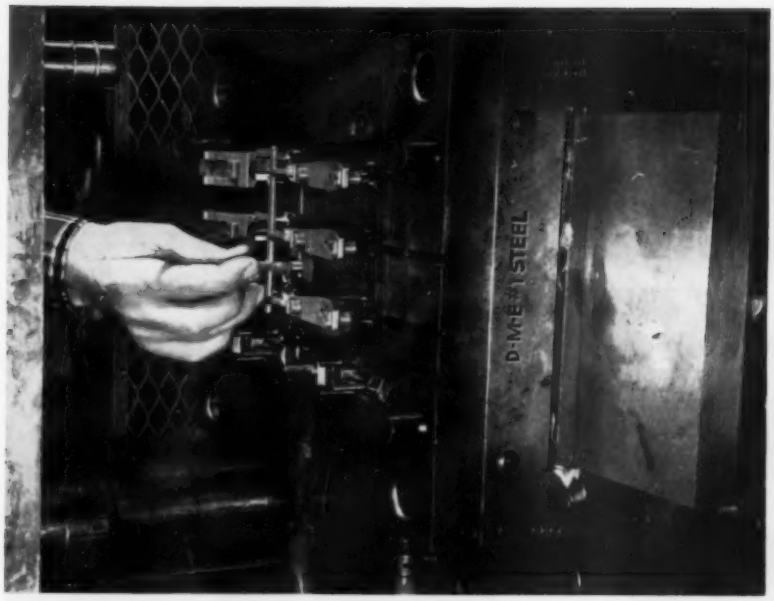

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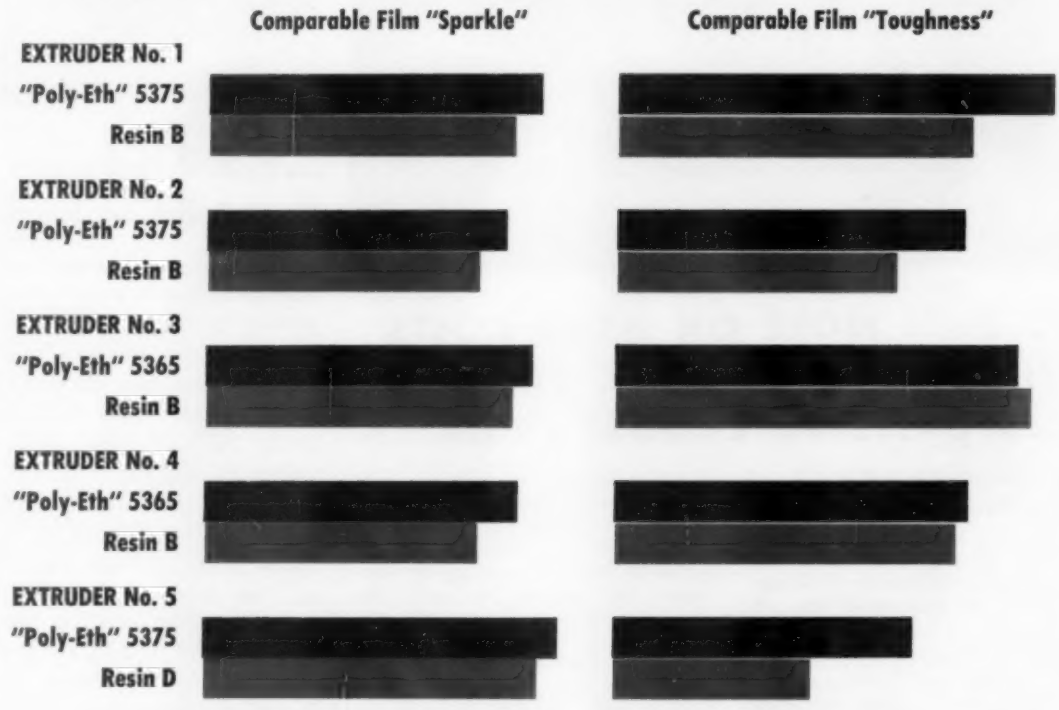
59-A

Advanced resin technology developed by Spencer

New Polymorphous Packaging Film With

Tests of Actual Production-Run Film Show How "Poly-Eth" 5300 Compares In Toughness and Sparkle:



It's easy to see that film made of Spencer's new polymorphous resins has a definite advantage over competitive materials. These charts were developed from film run by five different commercial extruders. Differences in values for the same resin result from variations in equipment and operating techniques. For complete information on these and other tests, contact your Spencer Representative.

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Packaging experts have long searched for a general purpose polyethylene film that contained *both* of these important properties: (1) the toughness necessary for rough handling and for long shelf life; and (2) the sparkling appearance needed to attract the customer and close the sale.

But now at last . . . toughness *and* sparkle have been combined in a single polyethylene film. This new and different kind of film is made possible by Spencer Chemical Company's development of "Poly-Eth" 5300 series resins. These resins are the result of a breakthrough in resin technology which produces what is called a "polymorphous" polyethylene resin.

Because they are polymorphous, these resins produce films with an unusually high degree of impact strength and tear resistance. Gloss is tops. Haze is held to a minimum. And yet this film is truly *tough*. At the same time, "Poly-Eth" 5300 series resins offer a complete balance of all other properties necessary in a general purpose packaging film.

Before being released for broad-scale film production, these polymorphous resins underwent an extensive series of field tests in commercial extrusion plants under a wide variety of processing conditions. In these tests, films made of "Poly-Eth" 5300 series resins were compared with films made of leading competitive resins. In nine out of ten cases, the "Poly-Eth" films were found to be definitely superior (see chart at left).

You are invited to compare a sample of this new film with your present film. For a roll of 1¼-mil flat film (50′ long x 11″ wide), contact your Spencer Sales Representative, or mail coupon with your business letterhead. There's no obligation, of course!

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Mr. Fred C. Sutro, Jr., Polyethylene Product Manager
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POLYMER SCIENCE

W. N. Findley — *Professor of Engineering*
Brown University, Providence, R. I.

Stress Relaxation and Combined Stress Creep of Plastics

This is Part 2 of a 2 Part Article—last month—Mechanism and Mechanics of Creep of Plastics

Stress Relaxation

Apparatus suitable for relaxation tests is shown in *Figure 11*. In such apparatus means is provided to make those adjustments, required as a result of the decreasing load, to maintain constant strain in the specimen. The load is measured by means of an elastic member. Stress relaxation occurs rapidly at first following application of the constant strain, but the rate of stress relaxation decreases with time. As an example, data obtained during relaxation of a rigid polyvinyl chloride at room temperature are shown in *Figure 12*.

Relaxation of real materials at constant stress cannot in general be adequately described by the simple mechanical models having a single relaxation time, although the general characteristics of the relaxation curve are predicted by the four-element viscoelastic model.

It is of considerable interest in engineering to be able to compute stress-relaxation behavior from known creep behavior at constant stress, and vice versa. Several methods have been employed including strain and time hardening, simple viscoelastic models, superposition and others. Some of these involve considerable mathematical difficulty as well as the physical question of whether the structure of the material changes in such different ways in creep and relaxation that creep and relaxation are essentially tests of two different materials.

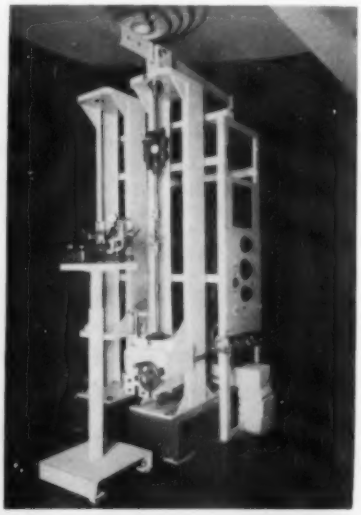

Figure 11. Apparatus for Stress Relaxation Tests (from Findley and Worley, Proc. SESA, in press).

In order to compute stress relaxation by the strain-hardening theory (Eq. 17) from a creep equation of the form of Eq. 11, the time derivative of Eq. 11 for constant strain ϵ may first be determined. When Eq. 17 is substituted for the second term, ϵ_p, of Eq. 11, on the assumption that Eq. 17 is the correct differential creep law, the following is obtained (19):

$$0 = (\epsilon_o'/\sigma_\epsilon)\,(\cosh \sigma/\sigma_\epsilon)\,d\sigma/dt + n\,(m' \sinh \sigma/\sigma_m)^{1/n}/\epsilon_p^{(1-n)/n} \quad 23$$

If from Eq. 11 $\epsilon_p = \epsilon - \epsilon_o' \sinh \sigma/\sigma_\epsilon$ is substituted in Eq. 23 the following integral is obtained for the relaxation of stress σ at constant strain, ϵ (19):

$$t - t_i = \frac{-(\epsilon_o'/m')^{1/n}}{n\sigma_\epsilon} \times \int_{\sigma_i}^{\sigma} \frac{[(\epsilon/\epsilon_o') - \sinh \sigma/\sigma_\epsilon]^{(1-n)/n} \cosh \sigma/\sigma_\epsilon \, d\sigma}{(\sinh \sigma/\sigma_m)^{1/n}} \quad 24$$

where σ_i is the stress at a time t_i shortly after application of the constant strain ϵ.

In a similar manner the time hardening relation Eq. 18 may be employed with somewhat different results.

These relations were evaluated using values of the constants in Eq. 11 obtained from creep tests of a rigid polyvinyl chloride. The calculations corresponding to the upper curve in *Figure 12* are shown as open and filled triangular points for the strain and time hardening theories

respectively. At long times the time and strain hardening theories fall below the test data.

The simplest relation between creep at constant stress and relaxation at constant strain would be that both are described by the same functional relationship between the variables stress, strain and time. One such relationship, Eq. 11, has been shown to describe creep of many plastics very satisfactorily. In order to test the applicability of this relationship for stress relaxation the strain ϵ may be assigned the constant value of the relaxation test and various appropriate values of stress σ may be substituted into Eq. 11 and the corresponding time calculated from the following inverted form of Eq. 11

$$t = [\ (\epsilon - \epsilon_o' \sinh \sigma/\sigma_\epsilon)\ /\ (m' \sinh \sigma/\sigma_m)\ ]^{1/n} \qquad 25$$

where the constants ϵ_o', σ_ϵ, m', σ_m are the values determined from the tension creep tests.

The results of such calculations are shown as black circles for both tests reported in *Figure 12*. As shown, the agreement is very satisfactory and better than the agreement with the strain and time hardening theories. Thus the simpler relation is found to yield the most satisfactory prediction. To date this relationship has been found to be in agreement with results of tests of a canvas laminate and an oxygen free copper, as well as the polyvinyl chloride.

The superposition principle has also been investigated as a means of deriving creep relations from stress relaxation test data (8, 17). Starting with equations of the form of Eq. 22, creep behavior has been derived from relaxation test data and compared with results of creep tests of short duration for methacrylate (19) and polyisobutylene (20). These calculations employed either evaluation of series expansions or numerical iteration.

Similar procedures can be employed to derive stress relaxation from creep by use of Eq. 21.

Recovery

Since the superposition principle has been found to be the most successful of four theories for predicting creep resulting from a change in stress it is reasonable to expect that it may be useful in predicting recovery following creep at constant stress. The equation for a sequence of two stresses, Eq. 20, may be employed. For recovery from a stress $\sigma_1 = \sigma$ the change in stress $\sigma_2 - \sigma_1 = -\sigma$. Thus the strain ϵ after removal of load at time t_1 becomes

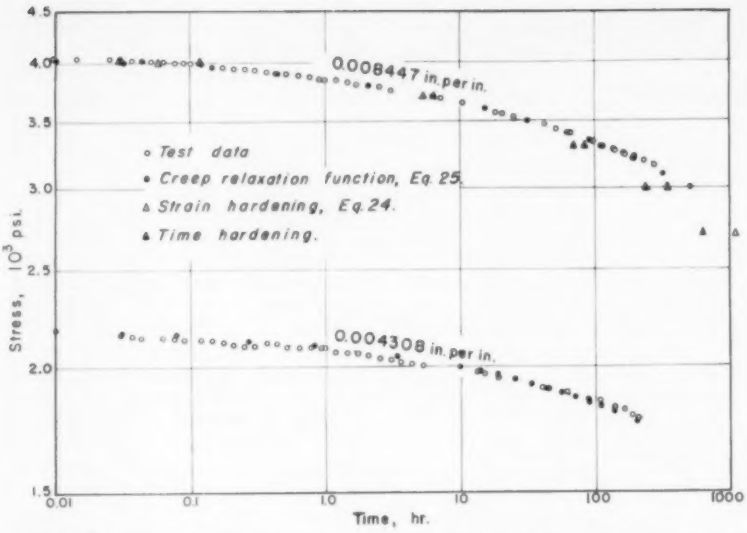

Figure 12. Stress Relaxation of Polyvinyl Chloride at Constant Strain for a Temperature of 77°F and Relative Humidity of 50 per cent. (from Findley, Proc., Third U. S. Nat'l. Cong. App. Mech., 1958).

$$\epsilon = [t^n - (t - t_1)^n]m' \sinh \sigma/\sigma_m \quad t > t_1 \qquad 26$$

As before this relationship employing $\sinh \sigma/\sigma_m$ is non-linear in stress so that superposition is not precisely applicable and Eq. 26 ignores the question of the path of stress vs. strain on instantaneous unloading.

Similarly the strain that would occur following reloading at time t_2 would be given by

$$\epsilon = \epsilon_o' \sinh \sigma/\sigma_\epsilon + [t^n - (t - t_1)^n + (t - t_2)^n]\, m' \sinh \sigma/\sigma_m \quad t > t_2 > t_1 \qquad 27$$

Equations 26 and 27 were used to calculate the recovery and reloading creep respectively following the long time creep illustrated in *Figure 6*. The magnitudes of the strains predicted were in fair agreement with test results as shown even though no correction was made for any lack of agreement between the test data and the predictions of the theory at the time of unloading. However, the predicted rates of recovery and rates of creep (slopes of the curves) on reloading were greater than actually observed.

Since Eq. 25 describes either creep or stress relaxation of rigid polyvinyl chloride with good accuracy it may be concluded that given either the stress or the strain existing in the material after a given period of time under constant stress or constant strain the stress and strain at that time will be the same regardless of which stress history was employed. For stress relaxation this means that the stress at a given time under constant strain is the constant stress which would cause the given strain in the given time in a creep test.

Using this interpretation recovery following stress relaxation may be calculated in the same manner as in a creep test using Eq. 26 and the stress existing just before the stress was removed. The results of such calculations and the corresponding test data are shown in *Figure 13*. The relaxation recovery data shown are from a relaxation test for which the initial stress was about the same (4,000 psi) as the stress in the creep test whose recovery is also shown in *Figure 13*. The stress in the relaxation test when the stress was removed was 3,200 psi as shown in *Figure 12*. The agreement between the calculated and actual values is quite satisfactory except that the predicted rate of recovery was greater than observed, as was found for recovery following the long-time tests, *Figure 6*, published last month.

Temperature-Time Superposition Principle*

It was observed for several plastics that creep curves for the same material tested at different temperatures could be joined so as to form one continuous line in which any single curve would be superimposed on the common curve (21). This composite curve can be constructed by plotting time logarithmically as abscissa, choosing the creep curve for one tem-

* A portion of this section has been taken from the author's chapter in reference (7) with the permission of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization.

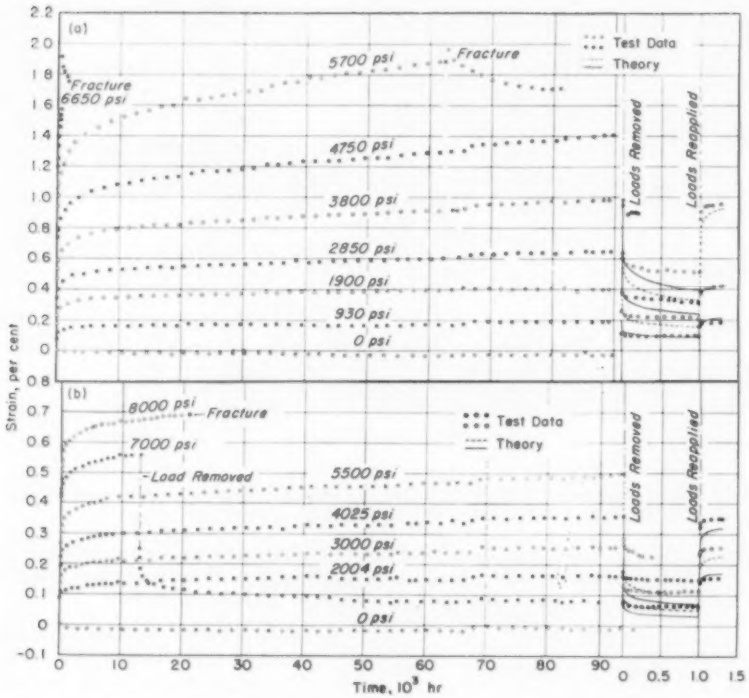

Figure 6. (from Part I). Rectilinear plot of Strain versus Time, Including Creep, Recovery and Reload for Laminates at 77°F and 50 Per Cent Relative Humidity. (a) Grade C canvas laminate. (b) Parallel-laminated paper laminate. (from Findley and Peterson, reference 12)

perature as fixed in position, and shifting the curves for other temperatures horizontally without change in shape until all curves form one continuous line. If, as is true for many plastics, a continuous line results from this construction, then for the given material a change in temperature is equivalent to a shift of the log time scale. This observation has been called the temperature-time superposition principle. It has been found to be applicable with reasonable accuracy to both creep and stress relaxation. This principle was proposed for plastics and has been employed for metals also. It is sometimes referred to as "temperature-compensated time." For materials which are in harmony with this principle it is possible to construct a creep curve or a stress-relaxation curve as a function of temperature-compensated time which is applicable for a wide range of temperatures and times.

A justification for the horizontal shift along the log t axis may be demonstrated for viscoelastic behavior as follows: In Eq. 2 for relaxation and Eq. 3 for creep of the Maxwell unit the temperature sensitive parameters are the modulus E and viscosity η. If the temperature sensitivity of the former is negligible and that of the latter is given by the general relation $\eta = f(T)$, where one possible form of $f(T)$ described above is $\exp(-\Delta f^*/kT)$, then for both creep and relaxation the time and temperature influence occur only in the combination $\theta = t/\eta = t/f(T)$. Taking logarithms of this expression the following is obtained:

$$\log \theta = \log t - \log f(T) \quad . \qquad 28$$

Thus when T is changed the values of $\log \theta$ corresponding to values of log t may be made to remain unchanged by adding a constant to the right-hand side of Eq. 28. The constant must be such as to compensate for the change in temperature. In a diagram in which the stress σ from relaxation or strain ϵ from a creep test is to be plotted to some scale as ordinate against log t as abscissa, the addition of a temperature compensating constant as described above is equivalent to shifting the entire diagram parallel to the log t axis.

It may be shown that a creep equation of the form of Eq. 11 is also subject to the temperature-time superposition principle if restrictions similar to those imposed on the Maxwell body are introduced. If the temperature sensitivities of ϵ_∞', σ_ϵ and n are negligible but those of m' and σ_∞ are substantial then the temperature-time superposition principle may be demonstrated for Eq. 11 by employing small values of stress such that $\sinh x \simeq x$. With the above limitations Eq. 11 may be placed in the following form by transposing the first term on the right to the left side of the equation and taking logarithms:

$$\log \{ (\epsilon/\sigma) - (\epsilon_\infty'/\sigma_\epsilon) \}^{1/n} = \log t/t_\circ + \log (m'/\sigma_\infty)^{1/n}$$

or

$$\log F(\epsilon, \sigma) = \log t/t_\circ + \log f(T). \qquad 29$$

Thus as described for Eq. 28 a change in T may be compensated by a shift of the log t scale.

The application of the temperature-time superposition principle to amorphous polymers is illustrated for polymethyl-methacrylate in *Figures 14 and 15*. *Figure 14* shows the original stress relaxation curves in which the ordinate is a function of stress and the abscissa is log-time. In *Figure 15* the data of *Figure 14* have been shifted as described above to form a composite curve. From this curve the performance at any temperature presumably can be obtained by shifting the log-time scale so that the time 10^0 (1 hr.) coincides with the desired temperature on the temperature scale of *Figure 15*.

According to Tobolsky (21) there seem to be four different regions (A, B, C, D in *Figure 15)* in the temperature-time behavior of amorphous polymers: A is a low-temperature glass-like region in which time effects are not very pronounced and not very sensitive to molecular weight, but depend strongly on the rate at which the sample is annealed; B is a transition region in which the polymer has a leathery feel and is very sensitive to time and temperature, but insensitive to molecular weight above a minimum value of molecular weight. The time effects are considered due to short range motion of small segments of the macromolecules; C is a rubber-like region of low time sensitivity in which the influence of molecular weight is small. The stress in this region is considered to be supported by entanglements between long chain molecules; D is a flow region of great sensitivity to time, molecular weight and molecular weight distribution. The flow in this region appears to be due to motion of molecules as a whole or motion of very large segments.

When a three-dimensional structure is formed by cross-linking of chain molecules through primary bonds the flow region D disappears and may be replaced at higher temperatures by flow resulting from breaking or interchange of primary valence bonds.

Creep of Plastics Under Combined Stress

State of the Art: The available experimental observations for creep or stress relaxation of plastic materials subjected to combined stresses are inadequate to evaluate the reliability of theories of creep or stress relaxation for plastics under combined stresses. However, the problem is an important one and the theoretical phase has received some attention. Alfrey (1) has given the following relationship connecting combined stresses s_i and strains γ_i for a Maxwellian material having a single relaxation time defined by the shear modulus G and viscosity η:

$$\frac{d\gamma_i}{dt} = \frac{1}{G}\sum_j a_{ij}\frac{ds_j}{dt} + \frac{1}{\eta}\sum_j a_{ij}s_j \,, \qquad 30$$

were the subscripts i and j take on values 1 to 6 denoting consecutively the three normal and three shear strains (or stresses). For an incompressible, isotropic, Maxwellian material the matrix a_{ij} is identical with the one describing the reciprocal elastic moduli of an incompressible isotropic elastic solid. Equation 30 results from application of the superposition principle. In a similar manner the relation between combined stresses and combined strains for a Kelvin model was also expressed as follows by using the above notation:

$$\sum_j a_{ij}s_j = G\gamma_i + \eta(d\gamma_i/dt) \,. \qquad 31$$

Either of the stress-strain relations, Eq. 30 or 31, may be combined with the differential equations defining compatability of strains. The resulting sets of equations may in principle be combined with the differential equations of equilibrium, and the boundary conditions for a specific problem, to define completely the stress, strain and displacement of a given point in the body as a function of the coordinates (x, y, z) of the point and the time t. For a Kelvin body with a single time constant as given by Eq. 31 the stress distribution (but not the strain distribution) is found to be independent of time and identical with the stress distribution in an incompressible, isotropic, elastic solid subject to the same boundary conditions, when the boundary conditions consist solely of prescribed forces.

Even for one time constant, solutions of the above equations are very difficult. Since even more complicated models are required to represent real material, the above method becomes too involved. Hence, Alfrey (1) has outlined a method which may be applied when the boundary conditions consist solely of prescribed forces and the expression for boundary forces may be expressed as a sum of terms each of which may be factored into a term which is a function of position f(r) times a function of time alone T(t). In this method the displacement that would result from f(r) alone acting on an incompressible, isotropic, elastic body is calculated from elastic theory and expressed in terms of the elastic shear modulus G.

The relation governing the time behavior of the material under simple shear is determined. Then in this relation the stress term s(t) is replaced by T(t) from the boundary function; the strain γ is replaced by 1/G and the expression is solved for G, which now is a function of time. The desired solution is obtained by substituting this expression for G as a function of time in place of the elastic shear modulus in the elastic solution for the displacement. A similar procedure permits determination of the stress (as a function of position and time) resulting from prescribed constraints. However, boundary conditions consisting of mixed forces and constraints can not be employed in this method.

A modification of this method has been applied by MacLeod (22) for several engineering applications involving creep of plastics and compared with results of actual tests. In these applications both creep and relaxation relations under uni-axial stressing were employed. The relaxation expression was obtained by fitting an equation to experimental data, and the creep relation was determined by one of the methods mentioned in the section on stress relaxation.

The solution of stress analysis problems involving creep of viscoelastic materials under complex stresses has been discussed by Lee (23) for general stress-strain laws of a type which are invariant under translation and rotation of axes.

Most relationships proposed to describe creep of metals under combined stress have been based on the following assumptions: (a) the material is homogenous and isotropic, (b) creep in tension and compression are equal, (c) the volume of the material does not change due to creep,

$$\epsilon_1^{(c)} + \epsilon_2^{(c)} + \epsilon_3^{(c)} = 0 \,, \qquad 32$$

where the superscript (c) denotes creep strain and the subscript denotes principal strain, (d) the directions of the principal stresses and principal strain rates coincide, (e) at any given instant the principal shear strain rates γ_i and the corresponding shearing stress τ_i are proportional, i.e.,

$$\frac{\gamma_1}{\tau_1} = \frac{\gamma_2}{\tau_2} = \frac{\gamma_3}{\tau_3} = \text{constant} \,, \qquad 33$$

and (f) the stress dependence of creep strain under combined stress is a function of the second invariant of the stress deviator J_2 (or the Mises criterion). When referred to principal planes J_2 may be expressed in terms of principal stresses σ_i as follows:

$$J_2 = \frac{1}{6}\left[(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2\right] \qquad 34$$

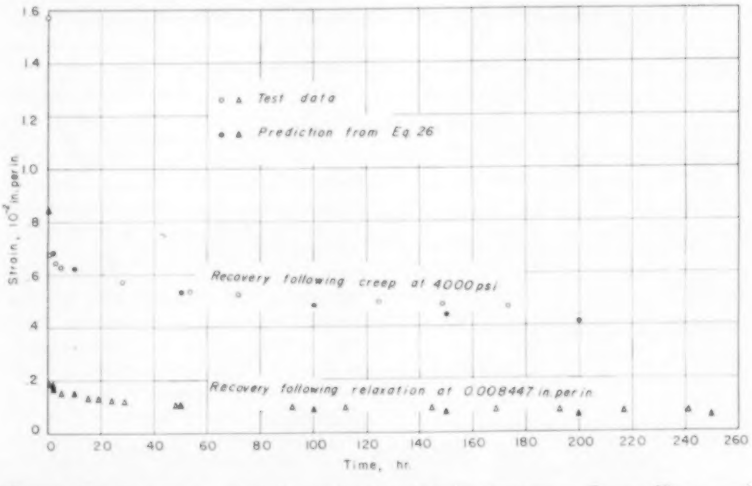

Figure 13. Recovery of Polyvinyl Chloride Following a Creep Test and Following a Stress Relaxation Test at 77°F and 50 per cent Relative Humidity. (from Findley, Proc., Third U. S. Nat'l. Cong. App. Mech., 1958).

Two different relationships have been proposed by Marin and Pao as being applicable to creep of plastics under combined stresses. The first of these (24) was based on the above assumptions, except for the second one. The relations were developed for bi-axial stresses where tension and compression creep were unequal. However, the creep-time relation was assumed to be a straight line, that is a constant rate, which is not an adequate representation of the creep behavior of many plastics. These relations were compared with creep tests in tenson, compression and torsion of methyl-methacrylate. In the second paper (25) the general assumptions (a) through (e) above were employed together with a stress-strain-time relation consisting of three separate terms, elastic, constant rate, and transient. The first term was assumed linear in stress, the other two were taken to be power functions of stress and the transient creep rate was taken to be a linear function of the transient strain. The resulting expression for uni-axial stressing was as follows:

$$\epsilon = \sigma/E + B\sigma^b t + K\sigma^b [1 - \exp(-qt)], \qquad 35$$

where E, B, K, b, q are constants of the material (the first being the elastic constant).

Comparing Eq. 35 with Eq. 4 it is evident that Eq. 35 represents the creep behavior of a four-element mechanical model in which the strain in the viscous element and in the Kelvin unit are power functions of stress instead of linear functions of stress. That is, Eq. 35 reduces to Eq. 4 when b = 1. Utilizing Eq. 32 and 33 together with an assumption that the stress dependence of both terms expressing the creep strain under combined stress were functions of J_2 Eq. 34, the following set of equations were obtained for creep under constant stress:

$$\epsilon_1 = [\sigma_1 - \nu(\sigma_2 + \sigma_3)]/E + \left[\sigma_1 - \frac{1}{2}(\sigma_2 - \sigma_3)\right] \times \{(1/2)[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]\}^{(b-1)/2} \{Bt + K[1 - \exp(-qt)]\} \qquad 36$$

where ν is Poisson's ratio.

Two additional equations for the other two principal strains are obtained by cyclic permutation of subscripts. It is readily verified that Eq. 36 reduces to Eq. 35 for $\sigma_2 = \sigma_3 = 0$. Also the constant volume condition during creep is represented by the fact that the coefficient of the $(\sigma_2 - \sigma_3)$ term is 1/2 in the first factor of the time dependent portion of Eq. 36. The 1/2 in this term corresponds to Poisson's ratio in the first term.

No experimental verification of these relations is available for plastics. However, Eq. 36 reduces to Eq. 13 for a constant uni-axial stress. Since Eq. 13 did not yield a satisfactory prediction of long-time creep of several plastics it may be presumed that Eq. 36 is likely to predict much greater creep after long times than actually observed for some plastics. For somewhat similar reasons the predictions of Eq. 30 would also be expected to yield much greater creep than actually observed at long times.

Power Function of Time: In view of the fact that Eq. 9 has been found to describe creep of several materials over a wide time scale with better accuracy than other simple relationships, it seems appropriate to formulate relationships of this type to describe creep under combined stress also. Since adequate experimental data are not available as yet to guide such a formulation the same assumptions as listed above (p. 195) may be employed. If assumptions (a) through (f) are retained and the stress-strain-time function is taken to be a power function of time, t^n, a linear function of stress in the time independent term and a power function of stress, σ^b, in the time dependent term, creep equations for constant combined stresses may be derived. These equations are as follows using the same notations as before:

$$\epsilon_1 = [\sigma_1 - \nu(\sigma_2 + \sigma_3)]/E + \left[\sigma_1 - \frac{1}{2}(\sigma_2 - \sigma_3)\right] \times \{(1/2)[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]\}^{(b-1)/2} t^n \qquad 37$$

These equations reduce to Eq. 9 for a constant uniaxial stress.

Because of the nonlinearity in stress it is difficult to express a combined stress creep equation having the form of Eq. 11 for uniaxial stress, which satisfies all of assumptions (a) through (f). Assumption (e) is especially difficult to satisfy. However, by applying the superposition principle with a stress-strain-time relation of the form of Eq. 11 the following equations satisfying most of the assumptions may be obtained:

$$\epsilon_1 = \epsilon_0' [\sinh \sigma_1/\sigma_m - \nu(\sinh \sigma_2/\sigma_m + \sinh \sigma_3/\sigma_m)] + m'\left[\sinh \sigma_1/\sigma_m - \frac{1}{2}(\sinh \sigma_2/\sigma_m + \sinh \sigma_3/\sigma_m)\right] t^n \qquad 38$$

Eq. 38 satisfies the constant volume assumption, Eq. 32, but does not satisfy assumption (f), and satisfies Eq. 33 only for stresses small enough that the hyperbolic sines may be replaced by their arguments.

It should be noted again that none of the above relations for describing creep of plastics under combined stress have received adequate experimental verification to date.

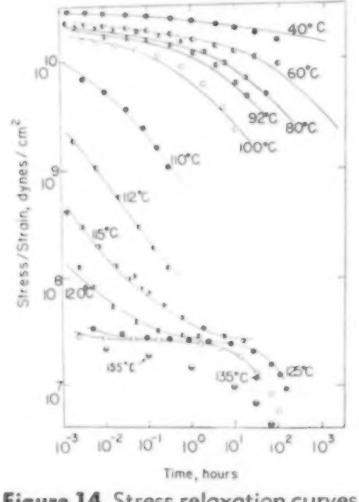

Figure 14. Stress relaxation curves for polymethylmethacrylate (from McLoughlin and Tobolsky, J. Colloid Sci., 1952).

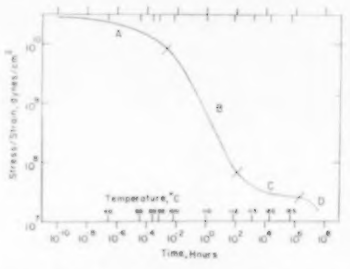

Figure 15. Composite stress relaxation curve for polymethylmethacrylate (from Tobolsky and McLoughlin, J. Polymer Sci., 1952, copyright 1952 by Interscience Publishers, Inc., N. Y.).

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(Continued on pg. 198)

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EUROPEAN FLIGHTS—1960

As to the Duesseldorf Plastics Exhibition in 1959 there will be the following group flights for SPE-members (and their family) in 1960:

June 17 New York—Brussels,—return July 4 Brussels—New York

purpose: plastics exhibition "EUROPLASTICA 60" Ghent, Belgium, June 18-26

—in case of sufficient support another earlier flight may leave New York June 10 with connection to Moscow, International Symposium for Macromolecules, June 14-18.

October 7 New York—London—Amsterdam, return Oct. 23 Amsterdam—N. Y.

purpose: International Synthetic Rubber Symposium and Exhibition, London, England, Oct. 11-13 and
International Congress for Macroplastics, Amsterdam, Holland and plastics exhibition "macroPlastic", Utrecht, Holland Oct. 10-12 and Oct. 19-26.

—in case of sufficient support another group flight could take place for industrial plant visits in Europe on July 30 New York-Vienna (Austria) and return Aug. 21 or September 11th Saltsburg, Festival, Aug. 24 New York-Rome (Italy) and return Sept. 11 (Olympic Games).

All flights will be on modern 4-engine aircrafts of one of the major airlines with first class service, most of them non-stop, some jet. The round trip fare on these charters will be $270 to $300.—per person. $20.—deposit with application is required and to be mailed to Dr. Heinz Neunteufel, 116-16 Audley St., Kew Gardens 18, L.I., N. Y. (office telephone 9 AM to 3 PM: EV-3-4350, Brooklyn). An early booking is advisable as especially the earlier flights are expected to be sold out by March. Commercial and technical assistance in Europe is available through the European, American Plastics Institute (Dr. Neuntenfel).

(continued from page 196)

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Edited by Irving Wolock
U. S. Naval Research Laboratory

PLASTICS AROUND THE WORLD

This month's column has been made possible through the contributions of these abstracters:
James M. Margolis (Plastverarbeiter)
W. A. Kelley (Electrical Manufacturing)
L. S. Buchoff (Materials in Design Engineering)
James Margolis (Kunstoff-Rundschau)

Germany

DER PLASTVERARBEITER

OCTOBER, 1959

New Polymers and Their Application—pp 410-411

The works of Ziegler and Natta introduced a new arena of synthetic olefins with stereospecific plastics, low pressure polyethylene and polypropylene. Their discoveries, for example, made possible isotactic polypropylene through modern polymerization methods. Polypropylene film with high heat resistant temperatures (160°) made by Minnesota Mining & Manufacturing Company from Hercules Powder Company's "Profax" (35,000 Mol. Wt. polypropylene) was demonstrated by Professor Herman Mark. High temperature resistant materials are becoming requirements for increasingly smaller delicate instruments and motors, especially in the U.S.A. for rockets, missiles and aircraft. Polytetrafluoroethylene (Teflon, Kel-F) are also finding use as high temperature materials. Long chain aluminum-oxygen molecules with Si-(phenyl) branches have been developed to be stable at 500°C and retain their organic character in being soluble in hot xylene. Polyarcrylonitrile, already used extensively in elastomers (Buna N) and textiles (Orlon fiber) can be made high temperature resistant through cyclization.

International Trade Show—p. 369

The show took place in Dusseldorf from October 17 to 25. According to this article, Germany showed itself to be in second place among nations in the plastics industry (U.S.A. being first). During the week prior to this exhibition, the "International Symposium of Macromolecules" was held by IUPAC (International Union of Pure and Applied Chemistry). Over one thousand scientists from all parts of the world met to hear 30 papers by physicists and chemists.

During the trade exhibition, one-third of floor space was taken up by machinery. Calanders for the production of flexible and rigid PVC film were displayed. New developments in extruders such as the hydraulic pressure meter; the "extra formatic," which permits automatic control for changing wall thickness and extrusion volumes.

KUNSTSOFF—RUNDSCHAU

OCTOBER, 1959

Makralon—pp 425-431

"Makralon" is the tradename of Farbenfabriken Bayer AG for their polycarbonate thermoplastic resin. According to this article the material was discovered in 1956 after several years research and is now being made at Verdingen. The material is classified as a linear, thermoplastic polyester according to its chemical composition. Another example of a commercially available polyester is polyethylene terephthalate. Polyesters of the polycarbonate and terephthalic acid types are very similar in many ways. Polyester of terephthalic acid is principally used for film and fiber due to its tendency toward crystallization. Aromatic polycarbonate, on the other hand, can be used for all types of thermoplastic products since it shows no tendency toward macrocrystallization, normally. Two forms are produced, one for injection molding and one extrusion which has a higher melt viscosity. The raw materials are 4,4'-dioxydiphenylpropane (Bisphenol A) and diphenyl carbonate, both carbonic acid derivatives. By modifying one or the other of the carbonic acid derivatives, essentially two different routes for making the polycarbonate are possible (equations shown). Polycarbonates are being used for a host of industrial and consumer items as well as in hospitals and other institutions. Examples are transparent bobbins, relay caps; telephone cases, glasses and dishes, bowls, drafting equipment (slide rules, triangles, straight edges), lighting fixtures and casements.

United States

MATERIALS IN DESIGN ENGINEERING

OCTOBER, 1959

Furane Coatings—John Delmonte, author

Furane coatings have good resistance to solvents, foods and beverages, salts, alkalis and many acids. Three types of resins are a thin penetrating coating, medium viscosity coating and a solvent type coating. An important limitation of these coatings is that they cost more than conventional organic coatings such as epoxies and phenolics.

Solid Urethane Elastomers—Malcolm W. Riley, author

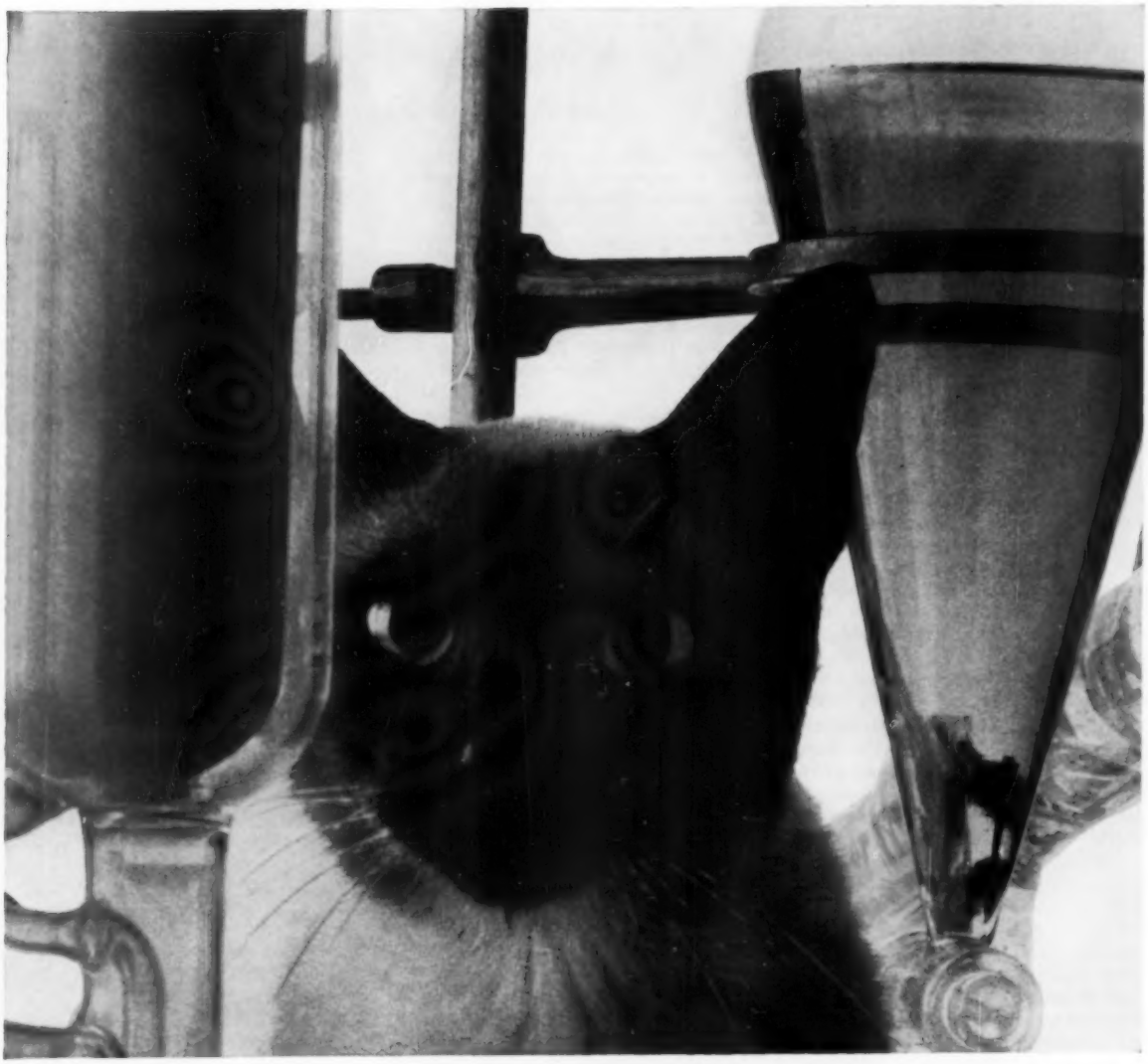
Urethane elastomers are hard, resilient, tough and abrasion resistant. They have excellent resistance to oxygen and ozone. Graphs and charts are presented giving their properties, and six commercial uses are described.

Electrical Manufacturing

SEPTEMBER, 1959

Effects of Thermal Environment on Laminated Plastics—S. W. Place, author

The effects of heat and moisture on the dimensional stability and mechanical and electrical characteristics of thermosetting laminates are discussed in relation to various test methods. Material is based on property evaluations and standards by ASTM, NEMA and Johns Hopkins University. A partial list of ASTM test methods most frequently used in evaluation of laminated plastics is also given.



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SPE JOURNAL

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OF PLASTICS ENGINEERING

The Food Additive Amendment And Packaging Materials

A. J. Lehman, M.D.
Food and Drug Administration
U. S. Department of Health, Education, and Welfare, Washington, D. C.

For plastics packaging materials makers:

- **What chemical data will you likely be called upon to submit**
- **Three major areas of concern—usage, composition, and extractability**
- **How to file a petition**

One of the most urgent questions confronting the manufacturer of a food packaging material today is this: Does the packaging material comply with the new Food Additives Amendment to the Food, Drug, and Cosmetic Act? Unfortunately, when the question is relayed to FDA, it is seldom able to give an unequivocal, clear-cut answer because of inadequate information on the particular product.

If component substances of the packaging material do not migrate to the packaged food or otherwise affect its characteristics, the answer is simple and direct: such substances are not food additives as defined by the Amendment, and hence no petition with respect to their proposed usage in the packaging material would be required, and further the packaging material itself, *in toto*, could be considered to be in compliance with the law. However, if any component of the packaging material does migrate to the food, a petition may be required, depending upon whether a prior sanction or approval exists, or whether the quantity of such component added to food is generally recognized as safe.

The use of plastics in packaging material is fairly recent and warrants special consideration. The finished wrap or container is not a simple mixture of easily identifiable components. Instead, the finished article may contain a dozen

Comment, by John G. Kuniholm, Legal Dept., Hercules Powder Co.

Many in the food packaging industry did not even become aware of the requirements of the Food Additives Amendment until they began to receive inquiries from their food industry customers asking about the FDA "status" of their packaging materials. Their blunt questions have been difficult to answer.

Question: Is your container approved by FDA for use in packaging food?

Question: Can you forward a copy of written correspondence you have had with FDA approving your material?

Question: Will you guarantee to hold us harmless from any liabilities we may incur if your materials are found to be unsafe for food packaging?

Jobbers and distributors of plastic materials, knowing little about their composition naturally passed the inquiries back to the molders and extruders. Molders and extruders first took the position that they were simply working with materials supplied by others who know more about their chemical composition than they. So they forwarded the questions on to the raw material suppliers. Raw material suppliers felt that they, having no control over what the molders did with their materials, had no duty to investigate their safety. Unaware of how much of the material the extruder was using in his formulation, with what other materials it was being used, or with what foods it would ultimately come in contact, they couldn't provide the answers. In short, everyone was involved but no one felt equipped to provide a complete answer. The first reaction was for each level of the industry to feel it was the others problem.

This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

or more components which are not single chemical entities. If any of these components migrate to food when in contact with the plastic material, the requirement is then to determine what is actually present in food and how much. The difficulties that may be encountered in developing analytical procedures to meet the above requirements can be readily recognized.

Ideally, the best procedure for determining whether any components of a food wrapper, container, coating, adhesive, or ink transfer to the food contacting it would be to package each of the foods for which use is contemplated in accordance with the proposed commercial usage, to hold or store at the highest temperature and for the longest period of time anticipated in actual usage, and then to analyze the foods for the packaging components; if and when possible, this procedure should be used. However, analytical methods are inadequate for analyses of most packaging components in foods at the high degree of sensitivity usually required, which may be of the order of 0.01 ppm. Therefore, as a practicable approach to the problem, we suggest extractability tests employing simple solvents to simulate the action of foods and beverages. Where usage is to be limited to packaging only dry nonfatty foods, specially devised abrasion or contact tests may be appropriate.

The tests should reflect the most extreme conditions to which the packaging material will be subjected in commercial usage. Since there are wide variations in this regard, no single set of test conditions can fit all cases with uniform propriety. However, there are three major areas which apply to all packaging materials, and detailed information and chemical data are required in each of these areas. These are: usage, composition and extractability.

1. Usage: Details of proposed usage: types of food (specific examples) to be packaged, maximum temperature of packaging, maximum temperature and time of storage, maximum temperature and time of cooking, (if food is to be subsequently cooked or processed in the package or container), minimum size of package (weight of food) to be used, and area and weight of film (including mil size) or coating exposed to food in the minimum size package.

2. Composition of finished packaging material.

(a) Quantitative composition of packaging material showing the content of both major and minor components (impurities), such as: basic resin polymers, monomers, plasticizers, stabilizers, catalyst residues, fillers, colors, etc.; (b) Formula showing molecular structure of the polymers; (c) Molecular weight distribution of the polymer(s) in the basic resin; (d) Specifications for the packaging material proposed by the manufacturer which bear on composition or probable solubility in simulated food solvents; (e) Description of the manufacturing process, including a statement of the side-reaction products or impurities expected and, if any, whether they are removed from the finished product and how.

3. Extractability data to show the probable degree of leaching of all components of the finished formulated packaging material under the conditions of proposed usage; and computations to show maximum contamination of food by trace impurities in the film or coating if all were transferred to the food.

If it is determined that migration does occur, then of course a determination as to the application of the Food Additives Amendment must be made. The first step is to determine the identity of the migrant, if possible. If it is not a substance which is exempt, then its safety for the intended use must be established. This will inevitably involve the filing of a petition.

Let us therefore next consider the petition and what it should include. When it has been resolved that the migratory substance is not exempt from the clearance provisions of the Amendment, what type of information must be submitted to get approval for the additive? The procedures are set forth quite clearly in Section 409(b) of the Amendment itself and in Section 121.51 of the regulations.

In brief, there are five basic points that must be covered in any petition. First, it should have all pertinent chemical information that is available regarding the additive; Second, the petition should show the extent to which the additive may be expected to migrate to food under the different intended or reasonably anticipated conditions of use; Third, the petition must contain data showing that the food additive will accomplish its intended physical or technical effect; Fourth, the petition should include a practicable method for determining the amount of the food additive in the finished food; Fifth, the petition must set forth all of the scientific studies made to determine the safety of the substance in food. To permit proper evaluation, this should include the details of unfavorable as well as favorable studies.

Once the petition has been submitted, the Department follows precise rules in acting on it:

A regulation may not be issued to permit an additive in food if:

(1) the data fail to show that the proposed use will be safe. (and the law specifically provides that no additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal, or if it is found by other appropriate tests to induce cancer in man or animals).

(2) the proposed use would promote deception of the consumer, or would otherwise result in adulteration or misbranding within the meaning of the Act.

Further, if a tolerance limitation is necessary to assure that the additive will be safe, the Secretary must not:

(1) Allow the additive unless it will accomplish the intended physical or technical effect, or (2) allow more of the additive than is reasonably required to accomplish such effect.

In determining whether a proposed use of an additive is safe, the Department is directed to consider, among other things: the probable consumption of the additive and of any substance found in or on food because of its use; the cumulative effect of the additive in the diet of man or animals, taking into account the effect of any chemically or pharmacologically related substance in the diet; and safety factors appropriate in the opinion of qualified experts for use in evaluating animal experimentation data.

In conclusion, what **the Amendment requires is a reasonable showing as to the identity and quantity of any substance migrating from the packaging material to the food under the conditions of use.** New test procedures for obtaining these data must be developed and older procedures improved. The Amendment places the responsibility for developing adequate testing procedures on the petitioner seeking approval of his food packaging materials, but we in the Food and Drug Administration are always willing to discuss any phase of the problem on which we can be helpful.

———■———

Single reprints of this article and the one following (Ingle) are available. Address requests to Editor, SPE Journal, 65 Prospect St., Stamford, Conn.

Currently, most colorants going into plastics materials used in food packaging are non-certified. This article discusses the ground rules which appear most useful and indicates directions for additional work.

Safety Of Colored Plastics Packaging For Foods

G. W. Ingle
Monsanto Chemical Co.

One of the unfinished pieces of business remaining from the first session of the 86th Congress is the proposed Color Additives Amendment to the 1938 Federal Food, Drug and Cosmetic Act. The intent of the Bill (S-2197) passed by the Senate was, in general terms, to apply to the use of colorants–which may appear as incidental or intentional additives in foods–the same philosophy of safe tolerances applied to other food additives under the 1958 Food Additive Amendment. The House bill, which was not passed, contained an anti-cancer clause which denies safe tolerances for any additive found "to induce cancer (as distinguished from all other toxic reactions) when ingested by man or animal, or if it is found after tests which are appropriate for the evaluation of the safety of food additives to induce cancer in man or animal".

In the 1958 Amendment, no specific mention was made of "coal tar" colorants. As a result, these are generally regarded today as exceptions and to be governed by other provisions of prior law. This means that certified coal tar colorants–dyes and pigments actually or possibly synthesized from compounds prepared from coal tars as opposed to those extracted from naturally occurring substances—are classified and then certified for compliance with certain rigorous chemical specifications for particular uses in food, drugs, or cosmetics.

A very few oil-soluble, and a larger number of water-soluble types (originally eighteen in total but more recently sixteen) and aluminum or calcium lakes of the latter may be used for all three categories. Other varieties–including lakes precipitated with strontium and barium and also oil-soluble anthraquinone dyes—which are popularly used in many plastics–are permitted for use in the progressively less critical categories of drugs and cosmetics and those restricted to external uses not in contact with mucous membrane. Last October FDA ruled to transfer thirteen important "D and C" colorants to the "External D and C" group; this ruling may be appealed and its effect delayed, if not voided.

The basis for this type of selection and control by certification is the thinking–beginning with the 1907 Act and prevalent in 1938–that most coal tar colorants were "harmful". As a result, only those coal tar colorants are permitted for use–in foods, or in drugs and cosmetics, internal or external–which have passed rigorous toxicological tests considered at that time to provide a reliable indication of harmlessness for that specific type of use. No colorant in each of the certified groups was to be used in any concentration, however *minute*, if the results of tests with any amount, however *large*, showed any harmful result. More recent toxicological data have shown the fallacy in this sharp distinction between "harmless" and "harmful". This philosophy has been superceded in the case of food additives which are not colorants by the 1958 Amendment, which accepts for all classes of toxic reaction to materials, except cancer, the principle of "safe tolerances". The basic concept here is that whatever the long term toxicity of a given compound–aside from cancerous reaction–there can be established some low concentration in the human diet which may be safely tolerated. Better understanding of the causes of cancer may remove the current exception from this otherwise general rule. The Color Additives Amendment, as it was originated in the last session of Congress and as it may be passed in the current session, includes this principle in large measure.

Legal Limitations

Until this change in the present inflexible law is made, we are confronted with this situation: **A large number of the colorants used in plastics packaging materials are coal tar colorants. Varieties of these certified for use in foods are, with very few exceptions, either grossly expensive for use in nearly all plastics materials or excessively unstable under the thermal conditions generally met in compounding and fabricating. Some oil soluble types most useful in plastics are permitted only in drugs and cosmetics–not in foods.** The result is that nearly all the colored plastics materials used in food packaging are colored with non-certified coal-tar colorants and with other inorganic colorants which are not coal tar in origin and which so far are treated as incidental food additives. Legally speaking, under the 1958 law, any use of uncertified coal tar colorants which results in migration to a food from the plastic package enveloping it, is illegal even if it may be safe. The use of colorants which are not coal tar in origin (such as inorganic and me-

TABLE 1—Status Of Colorants Used In Plastic Packages For Food

Type of Colorant	Present Legal Status (Assuming Migration)	Usefulness in Plastics
Coal-tar, dye or lake		
Certified	Legally Safe	Generally Unsuitable
Non-Certified	Illegal, even if safe	Broadly Useful
Non-Coal Tar		
Inorganic Pigment	Safe, via "prior sanction", or "general recognition as safe" or tolerance for Food Additive via regulation	Broadly Useful
Metallic Pigment		Broadly Useful
Natural Origin		Generally Unsuitable

This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

tallic pigments) may be both illegal and unsafe if such use does not comply with the Food Additives Amendment via prior sanction, general recognition as safe, or regulated tolerance. Toxicologically "zero" migration is safe.

Unless these current legal requirements are modified, for colorants in food intentionally or incidentally via migration, the plastics industry faces the problem of establishing for itself—and, in borderline cases, with FDA's confirmation—the safety status of colored plastics packaging materials. Here are described current ground rules which appear most useful, and directions for further work to clarify the situation. Uses of color are not considered which could deceive the purchaser on quality of packaged food, frequently judged by color.

Toxicological Factors

Today there is only one class of colorants "generally recognized as safe" in foods,—yellow, red, brown and black iron oxides. Three other important pigments originally thought safe—titanium dioxide white, ultramarine blue, and carbon black—were removed from the official "white" list published November 20, 1959, but it is expected that common types of these pigments will meet specifications establishing them as safe when incorporated in a plastic film, sheet or molding. In any case, these few colorants do not provide the spectrum of colors required for packaging materials.

Further, there are few data on the long term toxicological effect of commercial pigments in the human diet. Known effects are short-term (Table 2). Safe tolerances in foods cannot be set without long-term information. The question There is now no alternative to proving that migration of colorants from plastics does not exceed very low and toxicologically safe values, of the order of a few PPB, until better toxicity data are available.

This situation should not be viewed with alarm and hysteria. It needs analysis in terms of the cold hard facts which can be gathered from an understanding of the chemical compositions and toxicities of the colorants themselves, the generally small amounts which are used in plastics materials and the low tendency towards migration as this can be measured by extraction tests.

In terms of composition, *Table 3* lists the general tolerances allowed for toxic impurities in certified colorants used *in* food, as opposed to those for use in drugs and cosmetics: (other specifications exist which are peculiar to each colorant).

The tolerances in *Table 3* present some indication of the permissible levels of other pigments which may appear in foods by way of migration from a plastic package. The word "trace" needs definition; 0.01 PPM is an effective "zero" for many analytical methods, so that perhaps 0.1 PPM (up to 20 PPM?) may be considered a "trace". Cost and color limit amounts of certified colorants to below 0.4%. This, plus tolerances for heavy metals, gives a range of 10-40 PPB which may be appropriate for inorganic pigments in foods.

Turning to the concentration of colorants in the plastics packaging material itself, it is generally true that concentrations rarely exceed 1% of the plastic, excluding, of course, the achromatic white pigments. Depending upon the selection of the chromatic colorants which may be used in the formulation, the concentration will range from 1.0 gm/lb down to 0.0005 gms of colorant per pound of plastic, which is about 0.00012%, which is, in turn, 1.2 PPM. This low level may be less than the amount of heavy metals permitted in colorants used in food. This implies that the color styling of colored plastic packages should emphasize pastels.

If one considers the ratio of the weight of the food contents within the plastics package to the weight of the package itself, it is clear that the value of this ratio varies from 5 to 5,000 as the thickness of the packaging material and consequently its weight is reduced. The S.P.I. Bulletin on "Migration from Plastics Packaging", page 9, shows these relationships.

This means that if one assumes all the colorants in the plastics package to transfer to the food contents of 100 PPM, for example, initially in the plastics, only 1/500 or 1/1000 of this—depending on package geometry—could possibly be in the food itself. If, then, extraction is measured (as in SPI Bulletin "Migration from Plastics Packaging") only minute amounts of colorants will transfer to food-simulating solutions. The task is to measure migration to prove reliably that the levels of plastic colorants transferred to food is safely low. What's in the plastic doesn't matter,—only the amount and nature of materials which migrate to the food.

TABLE 2—Levels of (Acute) Toxicity for Illustrative Colorants Uses in Plastics for Packaging Foods

(Chronic Toxicities Unknown or Unavailable "Clinical Toxicology of Commercial Products")

Gleason, Gosselin and Hodge (Baltimore, Williams and Wilkins (1957)

Colorant	Acute* LD50(gm/kg)	Possible Tolerance in Foods (PPM)
Non-Coal Tar		
Cadmium Sulfide Yellow	0.005-0.050	0.01
Selenide Content up to 20% — Orange, Red, Maroon	?	?
Chrome Yellow	0.05-0.50	0.1(?)
Molybdate Orange	"	"
Chromium Sesqui-oxide	5-15	10(?)
Iron Blue	0.5-5	1
Coal-Tar		
Phthalocyanine Blue, Green	0.05-15(?)	?
Chinoline Yellow Lake (D & C #11)	?	0.01
Azo Pyrazolone Oil Yellow	?	?
Oil Red	?	?
Anthraquinone Blues, Greens, Purple, Red	?	?

* Meaning the concentration, in gms of pigment per kilogram of the test animal weight, sufficing as lethal dosage for half the animals so tested.

An Example

In one specific case, it was desired to color a polystyrene container for various frozen meats in interstate commerce. The color required a combination of cadmium sulfide pigments about 1% in total concentration. The geometry of package and contents was such that if *all* the cadmium pigments were to migrate to the contents about 120 PPM (100 PPM cadmium) would be found in the contents. The extraction tests were designed to be about 200 times exaggerated over use-conditions, and a polarographic test was chosen to detect extracted cadmium with a sensitivity of 1 PPM in the solution presented for analysis. Combining exaggeration and sensitivity factors, it is clear that the overall

TABLE 3—Permissible Impurities in Colorants for Foods, and for Drugs and Cosmetics

Applicable To	Impurity	Maximal Value	
		For FDC Colorants	For DC, Ext. DC Colorants
For "straight colors"	Lead	Less than 10 PPM	Less than 20 PPM
	Arsenic (AS as As_2O_3)	Less than 1.4 PPM	Less than 2 PPM
	Other Heavy Metals	Not more than a trace (by ppctation as sulfides)	Less than 30 PPM
Representative of impurities specified for individual colorants.	Ether Extracts	Less than 0.3% (3000PPM)	
	Soluble Chlorides and Sulfates	Less than 0.5% (5000PPM)	
	Inorganic Matter insoluble in HCL	Less than 0.5% (5000PPM)	
	Intermediates	Less than 0.1% (1000PPM)	

scheme was sensitive to 0.005 PPM in simulated use, one-half the 10 PPB tolerance for cadmium given by FDA. Because of this large exaggeration factor, it was necessary to prove that the extraction was not limited by saturation, to indicate a falsely low extraction. It was shown that except for the acidic FDA food simulating solutions, less than 0.002 PPM cadmium could be expected to occur in contents via migration from this package, thus, only 0.002% of all the pigment actually was extracted. The acidic (acetic and citric) solutions showed higher values, not exceeding 0-2 PPM, and these were rated irrelevant.

Practical Considerations

Proving no hazardous migration may be difficult, but not impossible. Ill-advised exceptions will arise. No competent colorist uses oil-soluble colorants in polyethylene to be used for fatty foods. The subsequent migration of the colorant, undoubtedly coal tar in origin, would be substantial and probably not safe; if safe, it is now illegal, though this could change via a Color Additives Amendment. In short, much depends upon the ingenuity of the colorist in selecting those colorants which are least soluble under the intended conditions of use and which, of course, meet all other qualifications in compounding, fabricating and in use.

How is the colorist to be guided in the selection of colorants for solubility? Lacking any other source of this information, he may determine extractibility of the colorant itself or of pieces of colored plastics packaging material by procedures suggested by the Food and Drug Administration, and include[1] in the S.P.I. Manual previously indicated Procedures, though certainly practicable, are rudimentary and appear to be, not well tested; at least no examples to the writer's knowledge have been published in the literature. Some use is known to have been made of these procedures for testing either solubility of the pigment in a food-simulating solution, or migration from the colored plastics packaging materials into the same solutions; the criterion of solubility or migration was visually perceptible coloration. A few experiments have been made which utilize the spectral absorption techniques recommended by FDA's Dr. Lehman.[1] Other experiments have been made which use analytical techniques such as polarography (above), to determine quantitatively and sensitively the amount of colorant extracted by the food-simulating solution. For most reliable results, one must occasionally experiment with a variety of analytical techniques available to find that one most applicable to the pigment in question.

Few direct consumers of colorants, except the larger suppliers of processed colored plastics can make such tests. The molders who dry-color are rarely equipped for such laboratory work or to contract for it in other laboratories. Nor are many food packagers—with major responsibility for compliance—so equipped. Work is being done by the manufacturers of colorants. This is, however, pitifully small in relation to the need but for understandable reasons. It must be admitted that the volume of pigments manufactured for plastics is small in comparison with those for paints, for example. Furthermore, the very complexity and variety of plastic formulations used for food packaging means that few data obtained for one plastic formulation may be used for another. (This complexity of formulation refers not only to the variations evident in amount and combinations of colorants, but also to differences in the polymeric portions of the total plastic formulation in addition to differences in additives, such as antioxidants, lubricants and other stabilizers, aside from methods of incorporation of the colorant into the plastic—each of which may be a controlling effect upon the migration of the colorant from the plastic.)

Recommendation

What appears needed is a long-term, well-programmed and wide-spread activity, by those with interests in the field of colored plastic for food packaging purposes, to concentrate upon the analysis of the most important cases. Possibly a standing committee within SPE or SPI could organize an industry-wide program to provide the data required. This program might well identify those colorant and plastic types of major volume interest, and possibly in coordination with the colorant industry or with committees within its trade societies, study the most important formulations. An important phase of this activity should be the planned publication of data obtained—on both extractability and toxicity—to establish a wider spread recognition of those combinations which this work would prove to be safe. In fact, there appears to be already available a substantial quantity of private information of these sorts, which if published and collated now, would begin to clarify the problem. Until such activity begins, whether organized or not, probably little more will be done than those isolated extraction projects now underway by the major suppliers of colored plastics materials. Results of this work will ultimately become known and applied, but only at the cost of much duplication and waste of technical effort and possible legal complications. It is also possible that failing such cooperative effort, the use of colored plastics packaging materials would simply be avoided and written off as an intolerable complication, thus losing one of the important sales advantages of plastics packaging materials over competitive materials. To avoid this result, intelligent analysis and cooperation, and not hysteria or pessimism, are needed.

1. A. J. Lehman, pg. 113 "Quart. Bulletin of the Assoc. of Food and Drug Officials of the U. S." (April, 1957).

This article adapted from a paper presented at the 16th ANTEC—Chicago—January, 1960.

"Bench side" information for the fabricators of vinyl—synthetic fabric laminates

Polyvinyl Chloride Adhesion To Synthetic Fabric

Charles F. Blaich, Jr. and Arthur J. Sampson
The Carwin Company

Fabric backed vinyl films and plastisols are used in many applications in industry today. Many of these uses are merely decorative and do not require unusual integrity of the finished product. However, in a large number of use areas, high load bearing capacity is demanded of the prepared materials in addition to resistance to attack by nature's elements. The high strength is obtained by using synthetic fabrics.

Many methods have been used to attempt to solve the problem of adhesion during the past few years with varying degrees of success. However, to date it has been virtually impossible to develop systems with adhesion under higher temperature conditions or with unusually high properties of adhesion.

One of the more successful methods tried to obtain high orders of adhesion was the utilization of a new type of chemical, the isocyanates, to modify various active co-polymers and ter-polymers of polyvinyl chloride. Unfortunately working stability of solutions and of pre-treated fabrics has prevented the general utilization of these systems. For example, earlier work on the problem of polyvinyl chloride adhesion to synthetic fabric, indicated that a polymeric isocyanate, polymethylene polyphenylisocyanate, when combined with a reactive vinyl chloride ter-polymer, gave excellent bonds by a simple solution application method. However, this system could not be worked in the plant because of sensitivity of the isocyanate to moisture, or because of pot life. Further investigation of other isocyanate compounded systems has yielded some very interesting results with Dianisidine Diisocyanate.

The system is a solution primer coat based on a vinyl chloride ter-polymer and Dianisidine Diisocyanate. The basic formulation is given in *Table 1*. The ter-polymer contains vinyl chloride, vinyl acetate and maleic anhydride and is commercially available from several sources.

The bond which is formed by the application of approximately one ounce per square yard dry of this material to various synthetic fabrics yielded adhesion as measured by the standard peel test in the range of 10 to 30 pounds per linear inch. This adhesion is surprisingly independent of fabric construction and may result with either spread coating of vinyl plastisols or lamination of vinyl films. In addition the high strength bonds may also be obtained with many synthetic fabrics, including nylon, dacron, glass, and rayon. There is very little variation in adhesion between the synthetic fabrics except where in the strength properties of the fabric are concerned. This is reviewed in *Table 2* which indicates the results obtained with various synthetic fabrics of similar construction.

When changing from a 5.1 ounce/square yard 21 x 23 count nylon fabric to a 2.3 ounce/square yard 40 x 40 count nylon, the adhesion only dropped from 25 to 21 pounds per inch.

The variation of the base coat formulation had very slight effect on the actual adhesion. The effect of formulation changes in regard to plasticizer content in the base coat may be seen in *Figure 1*. Here it may be seen that as the amount of plasticizer is increased to 100 parts based on the vinyl resin there is a decrease in adhesion when bonding vinyl plastisols. However, in lamination, an improvement in adhesion may be noted with an increase in plasticizer in base coat. This is also shown in *Figure 1*.

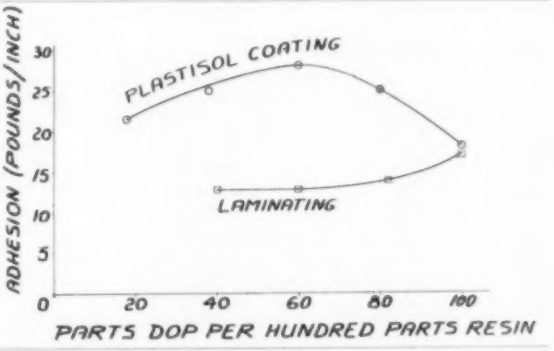


Figure 1. Variation of plasticizer in primer

The cure conditions used with the base coat have a pronounced effect on adhesion. In *Figures 2 and 3* the effects of varying cure temperatures are reviewed. These curves indicate that adhesion improves with time to give optimum results in each temperature range. However, it may also be noted that excellent adhesion, in the 15 to 20 pound range, can be obtained using a normal plastisol system and an air dry of the base coat.

The base coat, once cured, is stable on the fabric for at least nine months, and it is expected that it will be stable indefinitely. In *Figure 4* we can see that the adhesion changes resulting from the aging of the cured solution

TABLE 1—Composition of Primer Solution

Vinyl chloride, vinyl acetate, maleic anhydride ter-polymer	100 parts
Dioctyl phthalate	40 parts
Methyl ethyl ketone	200 parts
Dianisidine Diisocyanate	10 parts

TABLE 2—Adhesion with Different Synthetic Fabrics

Nylon	25 pounds/inch
Dacron	35 pounds/inch
Rayon	20 pounds/inch
Glass	fabric tears

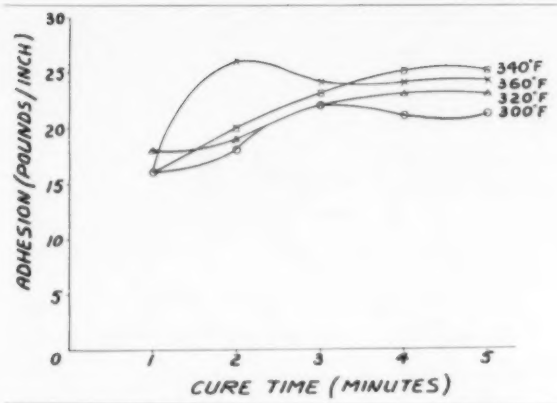


Figure 2. Effect of primer cure conditions

TABLE 3—Effect of Plasticizer on Adhesion

Plasticizer Type	Standard Plasticizer Concentration[1] (Parts Per Hundred Resin)	Adhesion (Pounds/Inch)
Dioctyl Phthalate	61	18
Didecyl Phthalate	76	23
Dicapryl Phthalate	65	22
Tricresyl Phosphate	67	22
Trioctyl Phosphate	59	19
Dioctyl Adipate	51	16
Dioctyl Sebacate	56	16
Epoxy—Type 1	70	22
Epoxy—Type 2	65	22

[1] Concentration to give 75% elongation at 1000 p.s.i.

coating on the fabric are within experimental error.

Although the test results to date only extend for nine months, this and other data seems to indicate that the mechanism of reaction of the Dianisidine Diisocyanate with the carboxyl containing ter-polymer system is one of crosslinking. Originally it was suspected that an actual reaction took place between the isocyanate group and the active hydrogen on the synthetic fabric. This reaction cannot be substantiated. Unfortunately, we have not been able to measure the effect on the modulus or other physical properties of the base coat system after the crosslinking with the Dianisidine Diisocyanate, but have found that the solvent

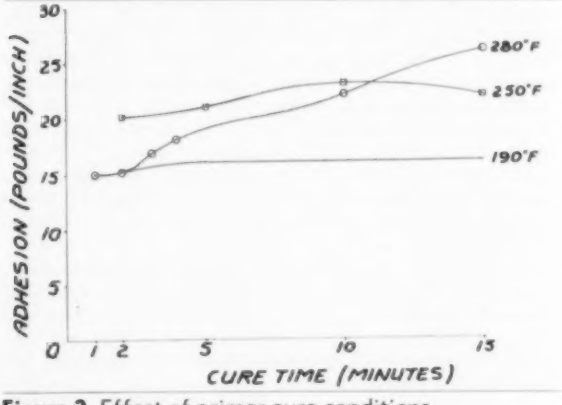


Figure 3. Effect of primer cure conditions

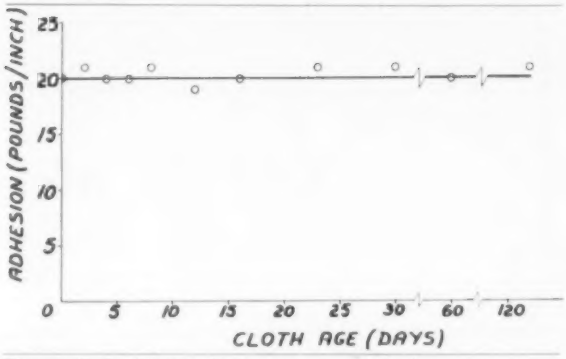


Figure 4. Stability of primer coated cloth

resistance of the base coat after curing is quite good. Other isocyanates, particularly those which are more reactive than the Dianisidine Diisocyanate, have been evaluated. It has been found that they work well, but that they also seem to crosslink the system too much, in effect giving a non-thermoplastic base coat which cannot be adequately fused to plastisols or vinyl sheeting to yield improved bonds. Also it has been noted that certain resins containing higher amounts of carboxyl group do not yield improved adhesion. Close examination indicates that the plastisol or vinyl laminate have not wetted the base coat treated fabric. Examination of the Dianisidine Diioscyanate in solvent systems by infra red analysis indicates a cyclization or other

TABLE 4—Effect of Wetting Agents on Adhesion

Wetting Agent	Concentration (Per Cent)	Adhesion (Pounds/Inch)
Fatty Alcohol Amine Sulfate	0.1	22
Cetyl Betaine	0.1	26
Iso Octyl Phenoxy Polyethoxy Ethanol	0.1	29
Iso Octyl Phenoxy Polyethoxy Ethanol	0.8	25
Iso Octyl Phenoxy Polyethoxy Ethanol	4.0	13

Figure 5. Proposed Cyclization of Dianisidine Diisocyanate

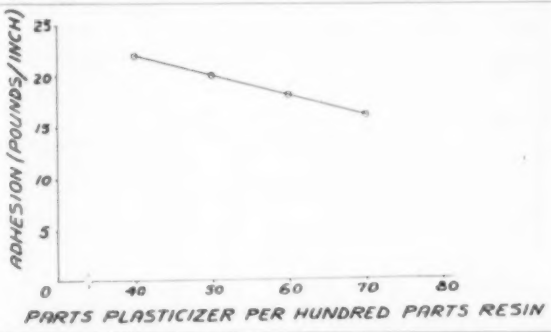


Figure 6. Variation of amount of plasticizer

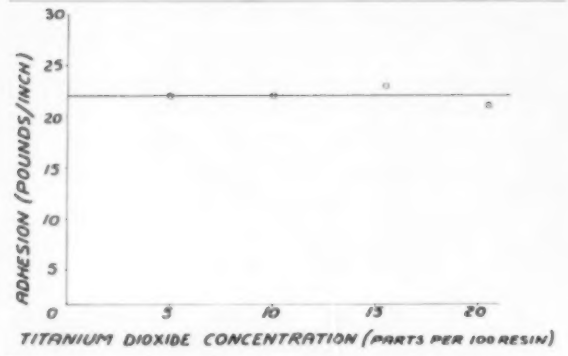


Figure 7. Variation of plastisol loading

internal blocking of the isocyanate by virtue of the ortho methoxy group as indicated schematically in *Figure 5*.

This could account for the unusual stability of the isocyanate in solution systems. In addition it would also substantiate a possible "B staging" mechanism on the initial curing of the base coat on fabric. Insufficient data is available to date to permit more than educated guesswork in this mechanism, but it is hoped that further work will accurately define the mechanism.

The compounding of the plastisol or vinyl sheets seems to be the most important phase in the determination of the actual adhesive bond which can be obtained. For example, if an extremely low modulus plastisol, such as would be used for low temperature application is used, bonds in the 10 to 15 pounds per inch range will be developed. In more normal type plastisols it will be found that adhesion in the 30 pound range can be obtained.

In vinyl plastisol formulations the effect of all plasticizers including the following types listed in *Table 3* have been reviewed.

The results of this evaluation indicated that plastisols compounded with the poorer solvating plasticizers have higher adhesion. Also the amount of plasticizer in the plastisol has a large effect on the overall adhesion. This is shown in *Figure 4*.

Generally it was found that the lower the modulus of the plastisol or vinyl laminate in question, the lower the adhesion. However, in no case does the adhesion fall below 10 pounds per linear inch on the normal ASTM peel test. The effects of loading or extending both with prime pigments and extenders was investigated. Little or no effect was noted in adhesion through as high as 20 parts of loading. These data are shown in *Figure 7*.

Stabilizers, both organic and inorganic, have little effect on adhesion. It was noted, however, that certain combinations of material interfere with the wetting of the plastisol

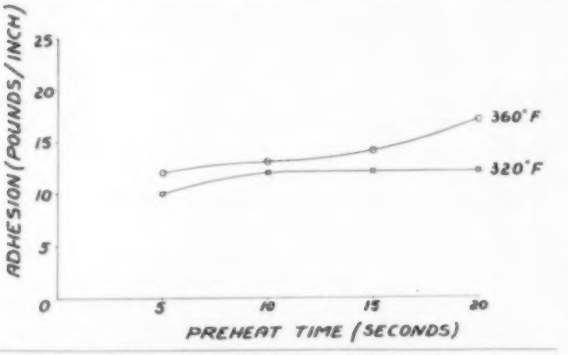


Figure 8. Effect of preheated vinyl film

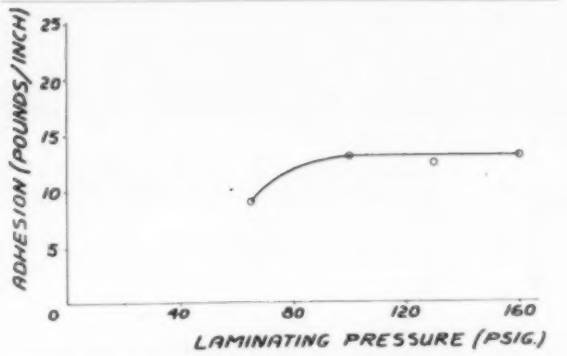


Figure 9. Effect of laminating pressure

to the primed fabric, and this in itself had a detrimental effect on adhesion. A further study of the use of wetting agents in the plastisol indicated that these effects could be overcome. These results are reviewed in *Table 4*. This evaluation indicated that optimum amounts of wetting agent could be used to assure better contact and better adhesion, but that "too much wetting agent" could adversely affect the system as well.

In lamination the time of exposure to maximum temperature is shorter than in plastisol coating; therefore, it is essential that the primer coat be fully cured when it is applied to the fabric. It was found that it was necessary to preheat the vinyl sheet in order to obtain optimum results in adhesion. These results are reviewed in *Figure 8*.

The effect of pressure on lamination does not have the marked effect that one would anticipate. As may be seen in *Figure 9*, differences are rather small and may be considered almost negligible above one hundred pounds per square inch.

TABLE 5—Composition of Plastisol Adhesive

Polyvinyl Chloride, Dispersion Grade	90 parts
Polyvinyl Chloride, Carboxyl Containing Co-Polymer	10 parts
Dioctyl Phthalate	70 parts
Epoxy Plasticizer	5 parts
Zinc Complex	2.5 parts
Barium-Cadmium Complex	0.5 parts
Dianisidine Diisocyanate	1

Initial results utilizing a carboxyl containing plastisol indicate that it may be possible to develop adhesive systems based on plastisols which will develop 10 pounds adhesion per inch with vinyl plastisol or sheets. The basic composition used is given in *Table 5*. The many evaluations which must be done in regard to varying plasticizer, pigment, stabilizer, and wetting agent, have not been completed. It is hoped that a complete review of this work will be possible at a later date. This system would prove more practical for many operations where high orders of adhesion would not be needed, but where improved adhesion is necessary. It also would permit faster coating and would not necessitate the requirement for solvent or explosion proof ovens.

In summation, it may be said that the utilization of Dianisidine Diisocyanate as a crosslinking agent in conjunction with ter-polymers based on vinyl acetate, vinyl chloride and maleic anhydride enables the development of unusually high order of adhesion for the bonding of vinyl plastisols and vinyl film to synthetic fabric.

A New Thermoplastic Material

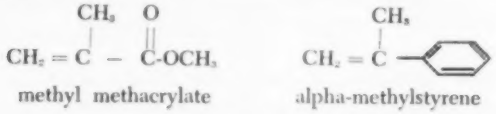
J. Briskin and C. H. Schramm

J. T. Baker Chemical Company Research and Development Laboratories

Lack of heat resistance has been a major deficiency in commercially available thermoplastics and has limited their usage to applications below 200°F. A new acrylic-type plastic, designated Baker PL-11, has been developed, with a unique combination of physical properties. This new material represents a considerable improvement over existing crystal clear thermoplastics, since it can be used satisfactorily at temperatures approaching 250°F. The plastic is in the market development stage and is available in experimental quantities.

Composition

Chemically, the new material is a copolymer of methyl methacrylate and alpha-methylstyrene The structures of the component monomers are shown below:



methyl methacrylate

alpha-methylstyrene

Both monomers contain methyl groups which are known to contribute to increased stiffness, high second-order transition temperatures, and greater solvent resistance. A very interesting feature is that the combination of the two specified monomers seems to give a synergistic effect with regard to heat resistance. The use of alpha-methylstyrene to raise the softening point of styrene polymers is well known, but the effectiveness is considerably less than with methyl methacrylate.

Physical Properties

The physical properties obtained on Baker's new plastic using standard A.S.T.M. methods are tabulated in the Table at right.

Examination of the tabulated data indicates that the most striking property of PL-11 is the high heat distortion values, even at 264 p.s.i. loading. The practical significance of this property is shown in *Figure 1*, where the flexural modulus data are plotted as a function of temperature. The curve indicates that the plastic retains a good share of its room temperature strength, even at elevated temperatures over 200°F. Comparison of the A.S.T.M. heat distortion values at different loadings indicates that the plastic exhibits the desirable property of retaining its heat resistance under moderate stress. While this is characteristic of amorphous polymers, it has been found that many "heat resistant" materials, such as polyamides and stereospecific polyethylene and polypropylene, which are crystalline in nature, are readily deformed when loaded at elevated temperatures.

TABLE I. Physical Properties of the New Thermoplastic

Property	A. S. T. M. Method	Units	Values
Heat Distortion:			
264 p. s. i.	D648	°F.	244-252
66 p. s. i.	D648	°F.	260-267
Index of Refraction	D542	—	1.519
Color	—	—	Water White
Tensile Strength, 77°F.	D638	p. s. i.	9,000
Elongation	D638	%	2
Flexural Strength, 77°F.	D790	p. s. i.	15,000
Flexural Modulus, 77°F.	D790	p. s. i.	480,000
Impact Strength, Milled Notch	D256	ft. lbs./in.	0.3
Specific Gravity	D792	—	1.17
Rockwell Hardness	D785	—	M102-105
Mold Shrinkage	—	in./in.	0.003-0.007
Dielectric Constant 10^3 c. p. s.	D150	—	3.00
Dissipation Factor 10^3 c. p. s.	D150	—	0.028
Dielectric Strength Short Time-⅛" thickness	D149	volts/mil.	475
Water Absorption: 24 hrs. Immersion at 77°F.	D570	%	0.2
Flammability: burning rate of ½"x½"x5" bar	D635	in./min.	1.7
Odor	—	—	None
Taste	—	—	None
Light Stability	—	—	Very Good
Machining Qualities	—	—	Good

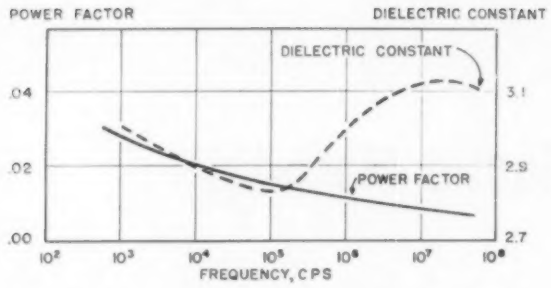


Figure 1. Effect of temperature on flexural modulus of new thermoplastic

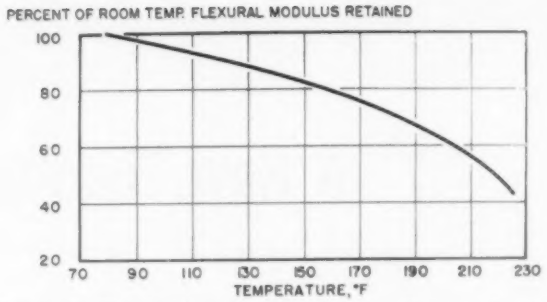


Figure 2. Electrical properties of new thermoplastic

The excellent heat resistance and low water absorption properties combine to give the new material the ability of withstanding boiling water. A sample has been exposed continuously for six months without showing any distortion or loss in clarity. In addition, specimens have withstood autoclaving through a number of 20-minute cycles at 5 p.s.i.g. steam pressure (227°F.) without any discernible changes occurring.

The color stability on aging is a very important property and has dictated the choice of a light stable plastic for many applications. Polymethyl methacrylate is noted for its outstanding light stability while polystyrene is considerably poorer. Samples of these plastics and PL-11 were exposed at Phillipsburg, New Jersey, facing south at 45° to the vertical, and the color development measured as a function of exposed time. The color was determined by the equation:

$$\%\text{Yellow} = \frac{\text{Transmissions at (620-420) millimicrons} \times 100}{620}$$

The results are given in *Table II*, below:

The results indicated that the new material should be very satisfactory for outdoor applications.

In general, it is soluble in many of the aromatic compounds, ketones, and esters which dissolve polymethyl methacrylate and polystyrene. However, it has shown such superior solvent and craze resistance in certain specific cases that attention is directed to this property. In certain applications it has shown satisfactory resistance to perchloroethylene, essential oils, and concentrated hot caustic solutions. The improved chemical resistance has proven to be extremely beneficial in applications where conventional acrylics and other clear thermoplastics display borderline craze or solvent resistance.

As expected, PL-11 being an organic plastic, exhibits non-conductive characteristics. Electrically, the material exhibits properties similar to methyl methacrylate polymers. The power factor and dielectric constant are functions of frequency, as shown in *Figure 2*, but the dependency is not very strong over the large range of cycles tested.

Processing

PL-11 has been processed by the techniques which have been developed for thermoplastic polymers. Flow rate data indicated that the melt viscosity was about 1.5 times that of polymethyl methacrylate over a shear range of 10-100 seconds^{-1}. Viscosity-temperature data indicated that raising the temperature about 15°F. will bring the melt viscosity down to the same level as polymethyl methacrylate. A number of processing studies verified the above analysis.

You'll Want to Read

How to improve processing behavior of vinyl homopolymers by admixture with specially formulated acrylic polymers—next month in the SPE Journal.

Investigation of stability to elevated processing temperatures and mechanical shear showed that PL-11 was fairly stable. Weight loss studies indicated a depolymerization rate of 0.02%/min. at 440°F. and 0.12%/min. at 480°F. The tests were run under conditions which removed the monomer immediately so that in processing equipment the depolymerization was actually lower. The stability to a combination of temperature and mechanical working was tested in a Brabender Plastograph (C. W. Brabender Instruments, Inc.), which is shown in *Figure 3*. The instrument is essentially a double arm kneader which is jacketed for temperature control. The resistance encountered in working the plastic is transmitted to a dynamometer which is equipped with a recorder. The results on PL-11 at different temperatures are shown in *Figure 4*. Examination of the curves shows that after the initial plastifying of the PL-11, the torque is quite constant, which would indicate good stability under the test conditions.

PL-11 has been successfully molded in a variety of injection molding machines and dies, as shown in *Figure 5*. The following recommendations should cover the majority of applications:

1. A pre-drying period of 2-3 hours at 200-220°F. to remove moisture.
2. Dies should be controlled at 160-220°F. and runners and sprues should be short with large diameters. The gating should be generous.
3. Cylinder temperatures of 350-475°F. should be adequate for most molding jobs. The higher temperatures will be necessary when molding pieces of thin cross-section.
4. Injection pressures of the order 20,000 p.s.i. will ordinarily be required for proper molding. Injection rate should be fast enough to fill the mold before the gate freezes without causing "jetting".

TABLE II. Aging Stability of New Thermoplastic

Material	% Yellow After Exposure		
	None	4 Months	12 Months
PL-11	1.9	3.0	3.9
Polymethyl methacrylate	2.0	2.5	3.4
Polystyrene	4.1	16.0	37.5

Figure 3. Brabender Plastograph

Under correct conditions, comparatively stress-free moldings of PL-11 can be obtained. Moldings which contain high stress concentrations will not give good service with respect to dimensional stability at elevated temperatures, or resistance to chemical attack. If a stressed condition cannot be overcome by correct processing conditions, the use of annealing to lower and redistribute the stress is suggested. Recommended temperatures are from 200-250°F., depending on the geometry and condition of the molding. After annealing at the higher range of temperatures, it is desirable to allow the temperature to fall gradually.

Extrusion of PL-11 into various shapes has been accomplished very satisfactorily as shown in *Figure 6*. On single-stage machines the plastic must be thoroughly dried. In general, 2-3 hours at 250°F. or 8-10 hours at 230°F. will be sufficient. Our experience indicated the equipment with the design features described below give the best results:

1. A full flighted screw with a compression ratio of about 2:1. A neutral screw proved to be most desirable.
2. In order to minimize back pressure, breaker plates and screen packs should not be used, and die lands should be as short as possible.

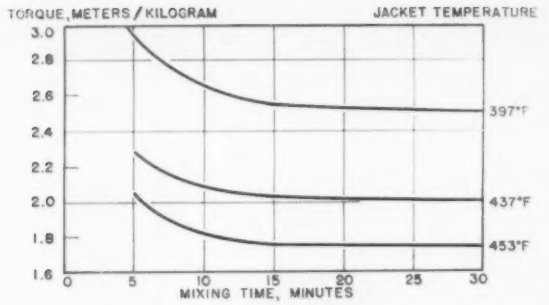


Figure 4. Brabender mixing curves of new thermoplastic at 63 rpm

3. Torpedoes or shallow metering sections are not recommended since they tend to increase the stock temperatures.
4. The correct extrusion temperatures will depend on the extruder, screw, and die design. A 2½" diameter machine extruded PL-11 rod and tubing of excellent quality at 400-440°F. barrel and die temperatures.
5. The screw should be kept on the slow side, i.e. 20-30 r.p.m.

PL-11 has been compression molded readily in order to prepare sheet and slab stock for prototype models. Temperatures of 300-350°F. and a force of 1000-2000 p.s.i. have been satisfactory.

In addition to the usual thermoplastic processing methods, the plastic lends itself to most fabricating and decorating techniques—including cementing, machining, painting and metallizing.

Applications

The physical properties of this new material have evoked industry-wide interest. Because of the excellent heat and chemical resistance, the plastic is being actively investigated by companies in the automotive, aircraft, optical, electrical appliance, instrument, pen, lighting, and packaging fields.

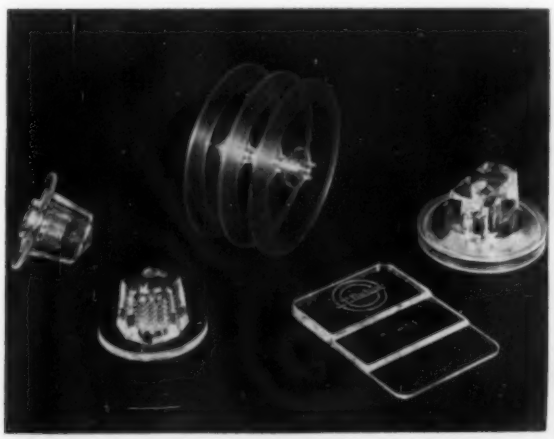


Figure 5. Injection molded samples of J. T. Baker's new thermoplastic

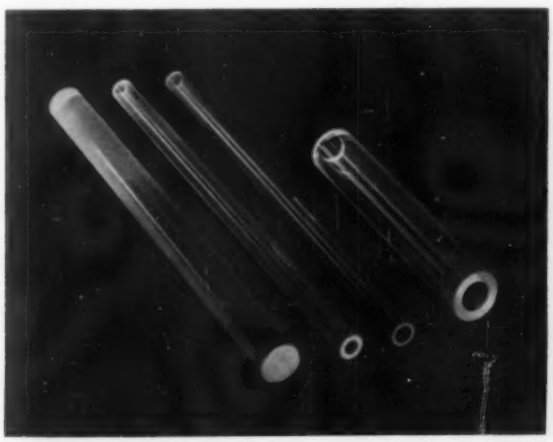


Figure 6. Extruded samples of J. T. Baker's new plastic

This article adapted from a paper presented at the 1st National Technical Conference—Los Angeles—October, 1959.

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Ed Hamway, Technical Director of the Textileather Division of The General Tire and Rubber Company says:

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"Thus, the true cost of a high quality plasticizer is not always the initial cost, but one that has been reduced by all these cost-cutting factors *plus* the assurance of a consistently performing vinyl product."

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Also available

★ **NATEC Preprint Book**—Volume I, 1959, Los Angeles, 20 papers. $5.00 members; $7.50 non-members (See program, September SPE Journal, page 788, and Abstracts on pages 815-817).

★ **Stability of Plastics**—Baltimore-Washington Section; Nine 1000-word abstracts. $1.00 members; $1.50 non-members (See program page 897, Oct. SPE Journal).

★ **Plastics in the Shoe Industry**—St. Louis Section, 11 papers, $3.00 members, $4.50 non-members. (See program, September SPE Journal, page 820).

★ **Plastics in Packaging**—Golden Gate Section, 12 papers, $3.00 members; $4.50 non-members. (See program, October SPE Journal, page 899).

OTHER 1959 RETEC PREPRINT BOOKS

★ **Vinyl Plastics**—Cleveland Section, 8 papers. $2.50 members; $3.75, non-members. (See program, SPE Journal, August, 1959 issue, p. 745).

★ **Plastics Finishing**—Buffalo Section, 4 papers, $2.00, members; $3.00 non-members. (See program, SPE Journal, September, 1959 issue, page 823).

★ **Encapsulation, Printed Circuits, and Fluidized Bed Processes**—Northern Indiana Section, 15 of 23 papers presented. $3.00, members; $4.50, non-members. (See program SPE Journal, April, 1959, p. 319).

★ **Plastics in the Automotive Industry**—Detroit Section, 4 papers, $2.00, members; $3.00 non-members. (See program SPE Journal, May, 1959, p. 443).

★ **A Designer's Look at Reinforced Plastics** from the Pleasure Boat, Aircraft and Missile Industries Viewpoint—North Texas Section, 6 papers. $2.00, members; $3.00, non-members. (See program SPE Journal, April, 1959, p. 324).

★ **Plastics in the Metals Industries**—Pittsburgh Section, 10 papers. $3.00, members; $4.50, non-members. (See program SPE Journal, April, 1959, p. 324).

SPE PLASTICS ENGINEERING SERIES

Vol. II—Processing of Thermoplastic Materials, 705 pages. $14.40, members; $18.00, non-members.

Vol. I—Quality Control for Plastics Engineers. $3.98, members; $4.95, non-members.

OTHER ANTEC PREPRINT BOOKS

Vol. V, 1959, New York City, 96 papers. $7.50, members; $12.50, non-members. Single preprints of individual papers, Vol. V, while they last, $0.25 each, members; $0.40 each, non-members.

Vol. IV, 1958, Detroit, 94 papers. $5.00, members; $7.50, non-members.

Vol. III, 1957, St. Louis, 60 papers. $5.00, members; $7.50, non-members.

SPI individual members are entitled to SPE members' prices under a reciprocal agreement.

Books will be mailed postpaid if money is enclosed. Please address orders to:

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Emery Industries (Canada), London, Ontario
Export Department, Cincinnati

FREDERICK C. SUTRO, JR.
President

THE PRESIDENT'S *Annual* REPORT

1959

GEORGE W. MARTIN
1st Vice President

JULES W. LINDAU III
2nd Vice President

FRANK W. REYNOLDS
Secretary

HAIMAN S. NATHAN
Treasurer

THOMAS A. BISSELL
Executive Secretary

Our Constitution says "The objective of the Society shall be to promote in all lawful ways the scientific and engineering knowledge relating to plastics."

It is the responsibility of every member to do his part in carrying out this objective. It is the duty of the President, the Officers, and the Council to make available to the members the ways and means by which this objective may be carried out.

There is a great temptation to look at those areas in which we have accomplished much and pass over those where we have done less. In all fairness, it is our duty to discuss both.

During 1959 our Society continued to grow in terms of membership, services and activities. The net increase of approximately 1600 members to a total of almost 8,000 is indicative of the awareness by men in our industry that SPE is and will continue to be, a highly valued membership.

In services, we have expanded our National Office staff under the very able leadership of our Executive Secretary, Tom Bissell, to enable us to publish a bigger and better SPE Journal and to offer more services to our members as well as to handle the increased membership.

In activities, the Society held a very successful Annual Technical Conference in New York, an excellent two-day National Technical Conference in Los Angeles and nine one-day Regional Technical Conferences at which the attendance averaged 285 each.

The administration and operation of all of this activity and services was simplified by the adoption of a new Constitution early in 1959. This enabled us to streamline our organization and redistribute responsibilities as well as authority so that no man had to carry an excess load.

Planning and development consumes much of the time of the Executive Committee. Some of the areas felt to be essential to the present and future growth of SPE are discussed briefly in the following paragraphs:

Three additional books in the SPE Plastics Engineering Series have been started. This is considered to be a very important function of SPE and it is hoped that the activity can be expanded.

The Technical activities of the Society have suffered during this early period in our growth. Financial and operational problems were so great that we had little time to spend on the engineering aspects of our industry. We have now established Professional Activity Groups which are the core of the Technical and Engineering activity of SPE. For SPE to accomplish its true purpose, these groups must grow in their importance and in their activity.

In years past our budget requirements have been such that we have had little opportunity to build a surplus. You can easily see from the enclosed Annual Financial Statement that we have very little surplus on which to fall back in the event of unanticipated reduced income. The 1959-60 Budget includes a 9% surplus and it is hoped that this contingency fund can be built over the next five to ten years to give us the financial stability required.

There are many opportunities for SPE to work with and assist high school, colleges and universities in education on plastics. This is best done through the Sections whom we urge to work with educational institutions in their immediate areas.

The rapid growth with which we have been favored has also brought continued problems in terms of organization responsibility and authority. The National Council now consists of 50 members with 44 National Councilmen representing as many Sections plus your National Officers. This is an extremely large group which will continue to grow and we are studying ways to increase the efficiency of our organizational structure.

This Report contains a detailed review by each of the Administrators, the Executive Secretary and Ad Hoc Committees. A review of these reports will make you more familiar with what your Society is trying to do.

My sincere thanks to the members of the Executive Committee and the National Council; also, to all members of SPE who have given so wholeheartedly of their time to make this an interesting and rewarding year for me. May we all continue to provide this same loyal support to our new President, George Martin.

Report of Administrator, Professional Activities Groups and Technical Committees,

FRANK W. REYNOLDS

PAGs and Chairmen:

1. **Plastics in Buildings, Ronald J. Carney**
2. **Plastics in Electrical Insulation, Walter A. Gammel, Sr.**
3. **Extrusion, John H. Myers, III**
4. **Reinforced Plastics, George Lubin**
5. **Injection Molding, Robert R. Moyer**
6. **Metals for Plastics Molds, L. J. Morrison**
7. **Castings and Plastics Toolings, Jerome D. Bassin**
8. **Forming, Donald A. Davis**
9. **Finishing, Gordon K. Storin**
10. **Thermosetting Molding, Elias G. Greninger**
11. **Vinyl Plastics, Robert Abeles**
12. **Polymer Structure and Properties, Robert R. Stromberg**
13. **Fabricating, Robert S. Lambert, Jr.**
14. **Standards for Reporting Properties, L. B. Allen**
15. **Plastics in the Automotive Industry, Richard C. Oglesby**

Technical Information Committee,
W. O. Bracken, Chairman

PAGs:

SPE's Professional Activities Groups continued to grow and develop during 1959. A new group was added: "Plastics in the Automotive Industry" bringing the number to 15.

Accomplishments of five or six of the most active groups serve to illustrate the benefits to SPE members and the plastics industry that may be achieved by vigorous groups guided by aggressive enthusiastic leaders. Highlights:

- Three "Extrusion Workshops" sponsored by the Extrusion PAG, introduced a new form of SPE service. Their unqualified success indicates that they filled an educational need.
- Plans for another SPE innovation—a traveling educational exhibit—were completed in 1959 by the Plastics in Buildings PAG. The tentative two-year schedule calls for six-week exhibits in 15 museums, universities, and architectural centers located through the country.
- During 1959 PAGs have contributed much to ANTEC, NATEC, RETEC, and Section technical programs. The Vinyl Plastics and Polymer Structure and Properties PAGs, have contributed technical papers, moderators, and suggestions to the 16th ANTEC program. The Vinyl PAG also assisted with the Cleveland RETEC on Vinyl Plastics and in the development of the Eastern New England Section's Professional Activity Committee on Vinyl Plastics.

Similarly, the Plastics in Electrical Insulation PAG cooperated closely with the SPE Northern Indiana Section on its RETEC program, as did the Finishing PAG with the Buffalo Section's RETEC on Finishing and the Plastics in the Automotive Industry PAG with the Detroit Section RETEC on this subject. The Reinforced Plastics PAG devoted major effort to development of strong Section PAG's in this area.

- Scheduling of PAG meetings so that they do not conflict with technical sessions at the 16th ANTEC in Chicago, should benefit all PAGs by stimulating participation in their annual organization meetings.
- Early in 1959 a step was taken to strengthen PAGs by increasing the signatures required on a petition for a new PAG from 10 to 25, and by requiring written evidence of objective, scope of activity, and potential for growth.
- Other projects include preparation of a bibliography of technical literature by the Plastics in Electrical Insulation PAG; liaison with SAE's Engineering Materia's Activity Committee and Reinforced Plastics Standards Committee by the Plastics in the Automotive Industry PAG.

Technical Information Committee:

During 1959 this Committee continued its effective behind-the-scenes service. Over 30 inquiries for technical information relating to plastics were answered.

Report of Education, Inter-Society Relations, and Plastics Institute Committee Administrator

JULES W. LINDAU III

Committees and their Chairmen:

Education Committee, C. C. Winding
Inter-Society Relations Committee, Jerome L. Formo
Plastics Institute Committee, Ralph L. Mondano,

EDUCATION COMMITTEE

This Committee has held two meetings during the year 1959 and will sponsor a luncheon and hold a Committee meeting during the 16th Annual Technical Conference.

Accomplishments of this Committee during the past year include establishment of rules for awarding scholarships: revision of the Guide Book for Section Education Committee Chairmen: development of additional information for Plastics Engineering Bibliography. The National Education Committee is undertaking publication of information on polymer and plastic engineering courses offered by universities and approved technical institutes for the use of the Society.

INTER-SOCIETY RELATIONS COMMITTEE

The Inter-Society Relations Committee has been active in maintaining liaison with more than twenty engineering and scientific societies. These societies have activities that are directly concerned with plastics or polymer science. The members of the Committee, assigned to individual societies, have reported in detail to our Chairman. He, in turn, has reported results to Council. Much of this information has been published in the Journal.

Outstanding accomplishments have been made by:

Norman Skow, who is the Secretary of ISO/TC61 on Plastics and has acted as SPE representative both in the United States and at meetings abroad.

William Lewi as SPE representative to the American Standard Association. This organization, that is known for its excellent performance in developing American Standards, has accepted SPE as official member concerned with standards of plastic materials.

Kenneth A. Kaufmann for heading the SPE group that keeps SPE in close touch with the important standards and specifications work being done by ASTM Committee D-20 on plastics.

PLASTICS INSTITUTE COMMITTEE

Three meetings of the Ad-Hoc Plastics Institute Committee have been held during the course of which a program for activity of this Committee was established. The National Council has approved a request for funds to be used in an educational and promotional program on the proposed Plastics Institute directed to the plastics industry. During additional meetings of the Committee, definite public-relations and research programs will be developed. At its October 26 meeting Council made the Plastics Institute Committee a Standing Committee, operating under the Education and Inter-Society Relations Administrator, instead of an Ad-Hoc Committee.

SOCIETY OF PLASTICS ENGINEERS, INC.

STATEMENT OF ASSETS AND LIABILITIES AS OF JUNE 30, 1958

ASSETS

Current Assets		
Cash—Fairfield County Trust Co.—Regular $17,029.61		
Cash—Fairfield County Trust Co.—Special 628.49		
Petty Cash 100.00		
Total Operating Cash	$17,758.10	
Cash Reserved—First Federal Savings & Loan	17,982.27	
Cash Reserved—The Seaman's Bank for Savings	11,238.30	
Advances—Sections	350.00	
Advances—1959 Conference	1,933.47	
Accounts Receivable—Advertisers	4,638.23	
Inventory of Books and SPE Journals	5,387.74	
Total Current Assets		$59,288.11
Capital Assets		
Furniture and Fixtures		1.00
Prepaid Items		
Post Office Mail Deposits	372.53	
Rent Security	1,714.50	
Prepaid Rent	521.50	
Office Supplies	1,200.00	
Total Prepaid Items		3,808.53
TOTAL ASSETS		$63,097.64

LIABILITIES AND SURPLUS

Current Liabilities		
Accounts Payable and Accrued Expenses	1,711.75	
Payroll Taxes Payable	1,550.94	
Total Current Liabilities		3,262.69
Reserves		
Contingency (Seaman's Bank for Savings—Contra)	11,238.30	
Research (First Federal Savings—Contra)	17,982.27	
Total Reserves		29,220.57
Surplus		
Balance—July 1, 1957	23,936.22	
Excess of Revenue		
Transferred to Surplus	6,678.16	
Total Surplus at June 30, 1958		30,614.38
TOTAL LIABILITIES AND SURPLUS		$63,097.64

STATEMENT OF ASSETS AND LIABILITIES AS OF JUNE 30, 1959

ASSETS

Current Assets		
Cash in Checking Accounts—Schedule 1	$10,131.38	
Cash Reserves—Schedule 2	37,525.12	
Petty Cash	100.00	
Accounts Receivable—Advertisers	9,834.62	
Inventory—Books and Supplies	6,990.60	
Total Current Assets		$64,581.72
Capital Assets		
Furniture and Fixtures		1.00
Prepaid Expenses and Deposits		
Post Office Mail Deposits	599.61	
Rent Security	1,564.50	
Travel Advances	725.00	
Payment to Dougherty & Co. per contract	15,000.00	
16th ANTEC Expenses and deposits	3,944.22	
Total Prepaid Expenses and Deposits	21,833.33	
TOTAL ASSETS		$86,416.05

LIABILITIES AND SURPLUS

Current Liabilities		
Accounts Payable and Accrued Expenses	9,451.28	
Rebates Payable—Sections	1,751.00	
Due from Operating Fund to Contingency Reserve	15,000.00	
16th ANTEC Registrations Received In Advance	4,925.00	
Dues Received In Advance	207.58	
Total Current Liabilities		31,334.86
Reserves		
Contingency (contra)	7,715.92	
Research (contra)	29,809.20	
Total Reserves		37,525.12
Surplus		
Balance—July 1, 1958	30,614.38	
Less: Excess Cash Transferred to Contingency Reserve	11,029.61	
Surplus Adjusted	19,584.77	
Excess Revenue	(2,028.70)	
Total Surplus		17,556.07
TOTAL LIABILITIES AND SURPLUS		$86,416.05

WHERE IT CAME FROM

	1958-1959	*1957-1958*
Membership Dues and Fees	$ 84,540	$ 70,948
Journal Advertising & Subscriptions	124,609	104,097
Annual Technical Conference	61,395	* 56,790
Miscellaneous Publications	23,634	6,360
Interest and Other	1,646	1,058
TOTAL INCOME	$295,824	* $239,253

WHERE IT WENT

	1958-1959	*1957-1958*
Section Rebates	$ 34,865	$ 31,903
Transfer to Reserves	12,275	7,224
SPE Journal	120,926	91,203
Annual Technical Conference	35,110	* 37,565
** Other Member Services	94,677	64,680
TOTAL EXPENSE	$297,853	* $232,575

* Figures of 1957-1958 statement increased $20,383 to show gross instead of net ANTEC figures to make comparable with 1958-1959 statement.

** Sections, PAGs membership, miscellaneous publications, RETECS, public relations and administration.

HOW MEMBERSHIP GREW

(All Figures as of June 30)

	BY REGION							BY NEW SECTIONS ADDED	BY TOTAL MEMBERS IN GOOD STANDING
	1	2	3	4	5	6	7		
1956	686	444	1370	648	254	882	282	3	4625
1957	784	564	1578	761	326	1038	365	2	5479
1958	844	640	1750	846	361	1168	440	2	6127
1959	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1 NEW ENGLAND
2 IROQUOIS
3 MID-ATLANTIC
4 EAST CENTRAL
5 SOUTHWEST
6 GREAT LAKES
7 WESTERN

Report of Administrator, Meetings

JOHN DELMONTE

Committees and their Chairmen:

Meetings, Joseph B. Schmitt
ANTEC Subcommittee, Guy A. Martinelli
NATEC—RETEC Subcommittee, Ray Mazur
Speakers Subcommittee, John A. Picard

During 1959 SPE Meetings established new standards of program quality, attendance and efficient operation. Registration at the 15th ANTEC, the First NATEC and the nine RETECS was 5,002 members and guests. Attendance at more than 400 Section Meetings held during 1959 probably exceeds this figure. The Meetings Committee developed long-range plans to meet future needs of the Society.

SPE's Fifteenth ANTEC (Annual Technical Conference) was held at the Commodore Hotel, New York City, January 27-30, 1959. Registration was 2,977; 112 papers were presented; and the Conference contributed a net of $26,285 to support the Society's activities. Co-General-Chairmen: James Growley and Guy A. Martinelli, representing Sponsoring New York and Newark Sections, respectively.

Plans for SPE's Sixteenth ANTEC point to another milestone in SPE's growth and development. Franklin L. Fine is General Chairman and the Chicago Section is Sponsor.

NATEC

SPE's first NATEC (National Technical Conference) was held on October 13 and 14, 1959 at The Ambassador in Los Angeles. The program featured 25 technical papers and two general luncheons. Held in conjunction with NATEC were a Banquet, saluting the West Coast plastics industry sponsored by the Los Angeles Chamber of Commerce and a meeting of the SPE Executive Committee. Registration was 460. Jack Fuller was General Chairman and SPE's Southern California Section was Sponsor.

RETECS

Again, attendance at Regional Technical Conferences (RETECS) broke all previous records, averaging 285 per meeting at SPE's nine 1959 RETECS:

1959 DATE	SUBJECT	SPONSORING SECTION	REG.
Apr. 28	Reinforced Plastics	North Texas	250
May 7	Plastics in the Metal Industry	Pittsburgh	160
May 22	Plastics in Electrical Insulation	Northern Indiana	445
June 30	Plastics in the Automotive Industry	Detroit	250
Oct. 7	Vinyls	Cleveland	310
Oct. 16	Finishing	Buffalo	140
Nov. 4	Plastics in the Shoe Industry	St. Louis	333
Nov. 19	Plastics in Packaging	Golden Gate	260
Dec. 1	Stability of Plastics	Baltimore-Washington	417
		Total	2,565

MEETINGS COMMITTEE

Changes in the SPE Conference Manual of Procedures will be recommended by the Meetings Committee to:

1. Expand and develop present ANTEC and NATEC Speakers Committees into a Program Committee of national scope with PAG participation, representing important technical segments of plastics engineering.

2. To supplement the above Program Committee, possibly as its Subcommittee, develop a Review Board to review papers submitted for ANTEC or NATEC programs.

Report of the Administrator, Publications

FRANK A. MARTIN

Committees and their Chairmen:

Publications, E. C. Quear
Technical Volumes, Hiram McCann
Editorial Advisory Board, Frank W. Reinhart

The past year was marked by a number of accomplishments in the Publications area, all of which are deemed beneficial to the Society. These changes occurred in all phases of our operations, including SPE Journal editorial and business management, Editorial Advisory Board and the Technical Volumes Committee. Staff members T. A. Bissell, M. A. Kohudic, L. R. Noe and L. A. Bernhard originated many of the innovations, and gave excellent cooperation to the Publications Committee in implementing all of the changes.

Journal Editorial:

Melvyn A. Kohudic assumed the Publications and SPE Journal Editorship in August, coming from Industrial and Engineering Chemistry. Changes were made in format, resulting in better appearance and readability. Pages were numbered consecutively for the year for easier indexing. A new cover was developed for use starting in January, 1960. Several new features were approved, among them a monthly newsletter highlighting new developments of interest to Plastics Engineers. Other features are under development. Technical summaries of programs of RETECS and ANTECS in news style were initiated. Fifty-nine technical articles were published and total pages increased from 904 in 1958 to 1118 in 1959.

Journal Business:

Circulation of the Journal increased 16% over the last half of 1958. Average print order was 8820 copies per issue. The policy of bringing the advertising sales management directly within the SPE office was amply justified by an increase of 35% in advertising volume for the year. The Journal was admitted to the Audit Bureau of Circulations during the year, and several attractive brochures were prepared as advertising sales tools. These two factors should greatly assist in bringing our advertising to a new high in 1960. A new source was developed for printing the Journal, and used during the latter half of the year. This has resulted in an average savings of $1.64 per thousand sheets printed. The increased advertising volume and reduced printing costs have for the first time made the Journal self-sustaining.

Editorial Advisory Board:

Dr. Frank W. Reinhart was named Chairman of the Board. Plans were formulated to increase the responsibilities of the Board and to make it a more vital factor in the editorial operation of the Journal.

Technical Volumes Committee:

The Technical Volumes Committee was raised to the status of a full standing committee with Hiram McCann as Chairman. The previously prepared volume "Processing of Thermoplastics Materials" was published and enjoyed a very good sale. The duties and modus operandi of the committee were prepared in manual form and approved by Council. Titles for the next three volumes have been selected and editors and authors are being screened. This program is now on a sound footing.

SPE History:

Editor Emeritus Dr. Jesse H. Day is preparing the first draft of the SPE history. It will be ready for Publication before our 25th anniversary.

Report of the Administrator, Administrative

H. S. NATHAN

Committee and their Chairmen:

Finance, H. S. Nathan
Constitution and By-Laws, A. W. Logozzo
Election Inspectors, E. L. Larkin
Public Relations, L. R. Greif
Nominating Committee, R. K. Gossett

The Administrative Committees are the unglamorous, non-technical watchdogs of the Society. Without their careful control over the business end, however, the basic function of the Society to disseminate plastics technical information could not be accomplished.

Finance Committee:

During 1959 the Finance Committee prepared and submitted the largest Society of Plastics Engineers operating budget since its incorporation. The total budget was approved in the amount of over $350,000.00. The financial statement of the Society as of June 30, 1959, included in this report, indicates a net worth in excess of $55,000.00. The long-range plans of the Finance Committee are to develop, within the next ten years, sufficient surplus reserves to operate the Society for one year—enough to implement reasonable amounts of plastics research without additional financing.

During 1959 study was made of the operation of the Executive Office in an effort to improve efficiency and minimize the large and cumbersome amount of detail presently required for normal operation of the Society. Several changes have already been incorporated with excellent results; such as revision to procedure for signing checks; elimination of many unnecessary mailings, and duplication of same; and addition of new equipment to process billings more readily. Further office systems study is under way to allow the Executive Office to keep pace with the steady growth of the Society.

Constitution and By-Laws Committee:

During the past year the Constitution and By-Laws Committee finally succeeded in preparing and publishing the revised Constitution with By-Laws and Index, adopted in February, 1959, by an overwhelming majority of members voting. The new Constitution allows for a more workable society operation and has been sorely needed for many years. The routine changes in By-Laws required by expanded activities of our Society are being handled in regular fashion by the committee.

Public Relations Committee:

The Society, recognizing the lack of proper Public Relations activity in the past, has appointed a strong functioning Committee and allocated initial funds for its implementation. Our Committee has outlined a public relations policy and program and the Executive Office has now employed an administrative assistant to carry out the initial stages of this program. We know that continued activity of this committee will gain for the Society of Plastics Engineers the stature and esteem that it has properly earned in the minds of the plastics and related industries.

Election Inspectors Committee:

This Committee handled the election of SPE Officers at our October 26th Council meeting with accuracy and dispatch.

Report of Administrator,
Sections and Membership

GEORGE W. MARTIN

Committees and their Chairmen:

Membership, James R. Lampman
Student Membership Subcommittee, John R. Berutich
New Section Development,
Ross Dean and O. B. Yorker
Credentials, George Baron and Donald Biklen
Sections, G. Palmer Humphrey

Membership Committee:

A total of 1,411 applications received in a ten-month period indicates that our Membership Committee's goal of 1,600 applications for the year will be reached. With a total of 7,072 members in good standing on December 1, 1959, President Sutro's goal of 8,000 members in good standing on January 31, 1960 will almost be achieved.

Activities of the Committee producing these fine results are featured by:

1. Regional Organization of the Committee with a Vice Chairman representing each Region to assist the Section Membership Committees within his Region to promote all grades of membership, including student members and to reduce the number of members delinquent in their dues.

2. Organization of a Student Membership Subcommittee which developed rules for establishment of a Student Chapter immediately followed authorization of the new student grade of membership, when SPE's revised Constitution was adopted in February. Soon thereafter, SPE's first Student Chapter at Lowell Technological Institute was chartered. In addition, the Subcommittee is assisting Sections to promote individual student members.

3. Introduction of an Inter-Section Membership Contest with the winner to receive a Championship Banner.

New Sections Development Committee:

Two new Sections—Florida and Monterrey, Mexico—were admitted during the calendar year, and development work has been carried forward in a number of promising areas, namely New Zealand, Australia, Arizona, and Western Michigan.

Credentials Committee:

By prompt and efficient grading of an ever-increasing flow of applications, our Credentials Committee is literally pacing the growth of our Society and also serving as watchdog over the quality of our membership. During the year the personnel of the Committee was expanded to nine members to distribute the increasing work load.

Sections Committee:

Work of this Committee centered on development of an urgently needed Sections Manual of Procedures. Following exchange of ideas on the subject at the meeting of Section Presidents at the 15th ANTEC in January, 1959, the Committee collected information from SPE Sections and from other engineering societies. After several Committee meetings and considerable interim work by Committee members, a voluminous draft of the Manual has been developed which is now being edited and condensed. Target date for completion is early 1960, so that the Manual can assist 1960 Section Officers.

PAST PRESIDENTS ADVISORY BOARD

P. W. Simmons, Chairman

Under SPE's revised Constitution and By-Laws, the Past Presidents' Advisory Board serves not only as an advisory group of experience and distinction, but as a Board to review and pass upon recommendations for Honorary and Distinguished Members. Other projects now being carried forward by the Board are the preparation of an SPE History and a review and evaluation of SPE's program of awards. Each of SPE's 16 living Past Presidents is automatically a member of this Board.

AD HOC COMMITTEES

Advertising in Section Publications: C. H. Whitlock, Chairman

The report of this Committee resolved a long-standing question. The report adopted by Council as part of a Rule, authorizes Sections to accept ads from processors and other companies or individuals located within their Section geographical areas as specifically defined in the Rule.

Councilmen's Travel Expense: R. A. Jenkins, Chairman

Considerable activity of this Committee included a survey of SPE Sections and sister engineering societies for their policies, practices and recommendations. The information collected was summarized in the report of this Committee presented to Council at its October 26 meeting. As a result of discussion at this Council Meeting, the report is being revised for submission to Council at its next meeting, January 11, 1960.

Future Organization of the Management of the Society: R. K. Gossett, Chairman

Following one meeting of this Committee and considerable discussion among the members, a preliminary report was presented to Council at its October meeting. At a second meeting on December 4, a specific plan was agreed upon for presentation at the January 11 Council Meeting for discussion only.

Report of Executive Secretary

THOMAS A. BISSELL

During 1959, SPE Headquarters Office and staff maintained and expanded its service to members, Sections, Council, Committees and PAGs.

To keep pace with the needs of our growing Society, the number of full-time employees was increased from 12 to 16. In July a new Publications Editor was employed and in December a new Administrative Assistant was added to concentrate on Sections, Public Relations, and Meetings.

In addition to your Executive Secretary, the following head up the SPE staff organization:

Lewis A. Bernhard, Manager, Administrative Department
Robert D. Forger, Administrative Assistant
Melvyn A. Kohudic, Publications and SPE Journal Editor
Leon R. Noe, Advertising Manager, SPE Journal

Highlights of 1959 staff service:

- In the meetings area, published preprint books for ANTEC and all nine RETECS; printed ANTEC and NATEC final programs in addition to advance programs for first time; publicized all programs in Journal and to National publicity list; handled ANTEC and NATEC membership mailings, paper solicitations and registration promotion; addressed envelopes for RETEC promotions; arranged for sale of SPE publications at ANTEC, NATEC, RETECs and Extrusion Workshops.

- Lowered Journal printing costs 20% by a change of printer; developed new Journal cover design and format; added Newsletter feature and preview of next issue; joined Audit Bureau of Circulations.

- Developed, published and distributed SPE Journal Advertising Brochure and promotion pieces for special Journal issues and for specific markets.

- Published this Annual Report, SPE's first.

- Published and distributed to Sections four National Newsletters.

- Promoted sale of SPE publications in Journal and at meetings so that revenue more than tripled 1958 figures. (See accompanying chart)

- Developed "Guideposts for Councilmen" and provided Councilmen with plastic binders for filing minutes, reports, agendas and correspondence.

- Ordered and distributed new enameled metal lapel pins.

- Duplicated and distributed notices, agendas, minutes and reports for most Committee and PAG meetings.

SOCIETY ACTION

President's Message and Goals
George W. Martin, 1960 SPE President

Our Constitution describes the means by which the Society achieves its objective as—technical meetings, publication of scientific and engineering reports and papers, exchange of technical information, and contributions to technical education relating to plastics.

It follows then that the charged responsibility of our Officers is to carry out to the best of their abilities the achievement of this—our Society's objective.

SPE's rapid growth, both in numbers and in achievements, attests to the fact that the Society has indeed been fortunate in the caliber and accomplishments of its past Officers.

We, your Officers for the year 1960, sincerely hope that at the end of our term of office, our endeavors and achievements will measure up to the fine performances of the past.

It is with this thought that we present to you the following goals of the 1960 administration:

1. PROFESSIONAL ACTIVITIES GROUPS
Frank W. Reynolds, Administrator

(a) Publish a revised PAG Procedures Manual.
(b) Restudy requirements for initiating PAGs and establish minimum requirement for continuing existing groups.
(c) Develop strong publicity and public relations program to increase the scope, membership, and activities of PAGs.
(d) Complete plans for—and put into operation—the first traveling exhibit on Plastics in Buildings.

2. EDUCATION, INTERSOCIETY RELATIONS, AND INSTITUTE
Haiman S. Nathan, Administrator

(a) Continue Education Committee's studies with regard to graduate scholarships, and submit recommendations by October 1960.
(b) Design and implement means to encourage effective Section Education Committee activity.
(c) Publish Manual for operation of Inter-Society Relations.
(d) Cooperate with other technical societies in development of proposed Plastics Library and Plastics Technical Information Center at Picatinney Arsenal.

3. MEETINGS
Franklin L. Fine, Administrator

(a) Establish SPE Program Committee to maintain the standard and broaden the scope of papers presented at ANTECs, RETECs, and Section Meetings.
(b) Further develop methods of improving facilities, arrangements, and effectiveness of presentations of all meetings of the Society.
(c) Develop and initiate multiple-day RETEC.

4. PUBLICATIONS
Maurice F. Malone, Administrator

(a) Achieve 550 pages of advertising in SPE Journal during 1960.
(b) Prepare for publication, January 1961, a new fundamental plastics engineering journal.
(c) Complete revision of Procedures Manual for SPE Journal.
(d) Prepare for publication by January 1961 volume on "Engineering Design for Plastics Parts".
(e) Prepare plans and project publication dates for additional volumes in the SPE Plastics Engineering Series.

5. ADMINISTRATIVE COMMITTEES
Joseph B. Schmitt, Administrator

(a) Prepare 1960-61 budget.
(b) Publish the complete revised Constitution and By-Laws and furnish each member of the Society with copy.
(c) Review, adopt and include in the Rules, all procedures manuals of the Committees of the Society.
(d) Establish the most effective public relations program possible, to assist the Society and its various Committees to accomplish their objectives, and to place the SPE in its proper place as the technical wing of the plastics industry.

6. SECTIONS AND MEMBERSHIP
James R. Lampman, Administrator

(a) Increase membership to 9,000 members by February 1, 1961.
(b) Accelerate the activities of Student Member Subcommittee to establish 5 new SPE Student Chapters.
(c) Improve communications between the Society's and Section Credentials Committees, to maintain standards of membership.
(d) Complete, publish, and implement the revised Sections Procedures Manual.
(e) Provide equal opportunities and benefits for all members by proper location of geographical Sections.
(f) Further explore the possibilities of foreign Sections, to increase our service to members in other countries.
(g) Further develop the opportunities to build membership offered by ANTECs, RETECs, and Section Meetings.

7. AD HOC COMMITTEES
(A)—FUTURE ORGANIZATION OF MANAGEMENT OF SPE
R. Kenneth Gossett, Chairman

Complete study of future management of SPE and recommend a program to Council for approval by May, 1960.

(B)—COUNCILMEN'S TRAVEL EXPENSE
Richard A. Jenkins, Chairman

Secure final action on the report and recommendations of Committee.

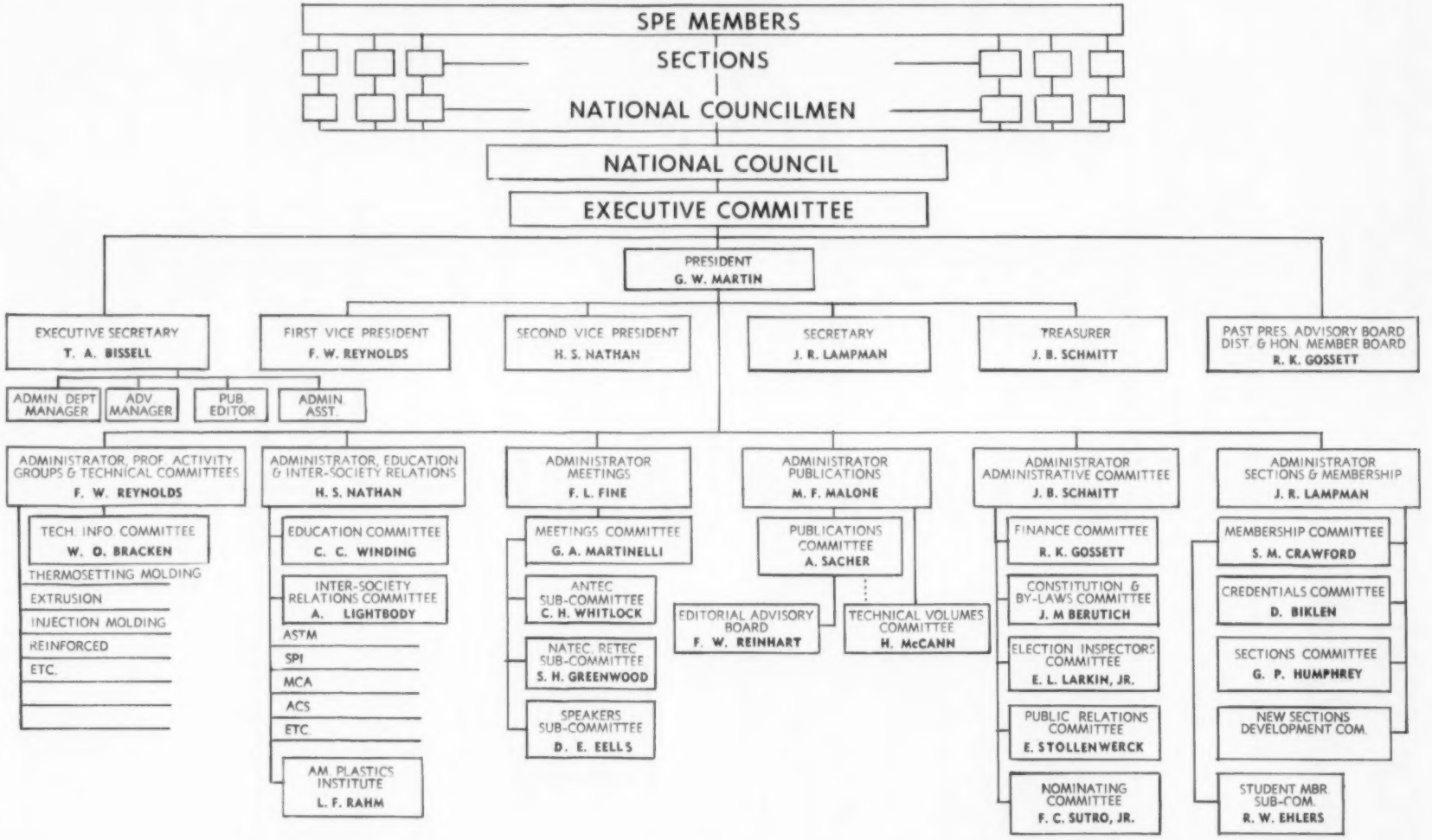
8. PAST PRESIDENTS ADVISORY BOARD
R. Kenneth Gossett, Chairman

(a) Study and recommend policies for SPE awards, January, 1961.
(b) Prepare "SPE History", January, 1961.

(Continued on page 231)

SPE ORGANIZATION CHART

WITH THE 1960 NATIONAL ORGANIZATION



SPE's 1960 ORGANIZATION

1960 OFFICERS

George W. Martin, *President*
Frank W. Reynolds, *First Vice President*
Haiman S. Nathan, *Second Vice President*
James R. Lampman, *Secretary*
Joseph B. Schmitt, *Treasurer*
Thomas A. Bissell, *Executive Secretary*

COUNCILMEN

Akron
NICOL, W. H.—1963

Baltimore, Washington
LIGHTBODY, ALBERT—1962

Bartlesville-Tulsa
CAMPBELL, PAUL E.—1963

Binghamton
GWYN, JOHN E.—1961

Buffalo
GRENIER, JOSEPH—1963

Central Indiana
QUEAR, EUGENE C.—1961

Central New York
LAMPMAN, JAMES R.—1961

Central Ohio
KUHLMANN, HENRY W.—1961

Chicago
FINE, FRANKLIN L.—1962

Cleveland
CRAWFORD, SHERMAN—1962

Connecticut
COUGHLIN, WILLIAM J.—1963

Detroit
WHITLOCK, CARL H.—1962

Eastern New England
MONDANO, RALPH L.—1961

Florida
PFUNTER, JORDAN—1962

Golden Gate
SMITH, JAMES C.—1963

Kansas City
THOMSON, ROBERT

Kentuckiana
BERUTICH, J. M.—1962

Miami Valley
KULP, JOHN F.—1962

Milwaukee
WEST, PAUL A.—1963

Monterrey
BRECKER, JOHN P.—1961

Newark
BIKLEN, DONALD—1961

New York
HUMPHREY, G. PALMER—1961

North Texas
JENKINS, R. A.—1962

Northern Indiana
LEE, MAX M.—1962

Northwest Pennsylvania
LEET, DONALD—1961

Ontario
NOBLE, RALPH—1962

Osaka
NAKAO, TADAO—1962

Pacific Northwest
KORRY, BORRIS V.—1961

Philadelphia
GREENWOOD, SAMUEL H.—1962

Pioneer Valley
MOORE, JOHN T.—1962

Pittsburgh
SCHMITT, JOSEPH B.—1961

Quebec
MALONE, MAURICE F.—1961

Rochester
HAYES, RICHARD L.—1963

Rocky Mountain
HAUSER, RAY L.—1963

St. Louis
EELLS, DONALD—1962

South Texas
DUNLAP, WILLIAM—1963

Southeastern New England
DAHL, NILS J.—1963

Southeastern Ohio
PETRETTI, MARIO J.—1961

Southern
(To be elected)

Southern California
DELMONTE, JOHN—1961

Toledo
ERARD, THOMAS G.—1963

Tri-State
UTLEY, WILLIAM F.—1962

Upper Midwest
ULRICH, IRWIN W.—1963

Western New England
MAZUR, RAYMOND A.—1962

COUNCILMEN-AT-LARGE

George W. Martin, Haiman S. Nathan, Thomas A. Bissell, Frank W. Reynolds, Frederick C. Sutro, Jr.

EXECUTIVE COMMITTEE

George W. Martin, Frank W. Reynolds, Haiman S. Nathan, James R. Lampman, Joseph B. Schmitt, Franklin L. Fine, Maurice F. Malone, Frederick C. Sutro, Jr., Thomas A. Bissell

PAST PRESIDENTS

Fred Conley (1942)
W. M. Phillips (1943)
Charles C. Henry (1944)
William B. Hoey (1945)
George W. Clark (1946)
T. E. Orr (1947) Deceased
J. Harry DuBois (1948)
Mario J. Petretti (1949)
C. Todd Clark (1950)
Islyn Thomas (1951)
William O. Bracken (1952)
Walter F. Oelman (1953)
John W. LaBelle (1954)
Frank W. Reinhart (1955)
Jerome L. Formo (1956)
Peter W. Simmons (1957)
R. Kenneth Gossett (1958)
Frederick C. Sutro, Jr. (1959)

COMMITTEE CHAIRMEN APPOINTMENTS

Past Presidents Advisory Board

R. Kenneth Gossett (Chicago)

Professional Activities Groups

ADMINISTRATOR
Frank L. Reynolds (Binghamton)

1960 PAG Chairmen, elected at the annual meetings of their various groups held during ANTEC, will be reported in the March issue of the Journal.

Technical Information Committee

W. O. Bracken (Philadelphia)

Education, Inter-Society Relations, and Plastics Institute

ADMINISTRATOR
H. S. Nathan (Buffalo)

EDUCATION
Charles C. Winding (Rochester)

INTER-SOCIETY RELATIONS
Albert Lightbody (Baltimore-Washington)

American Association for Advancement of Science
(To be appointed)

American Chemical Society
Irvin I. Rubin (New York)

American Electroplaters Society
(To be appointed)

American Institute of Architects
(To be appointed)

American Institute of Chemical Engineers
(To be appointed)

American Institute of Electrical Engineers
(To be appointed)

American Ordnance Association
Oscar B. Yorker (Rocky Mountain)

American Society for Engineering Education
Jules W. Lindau, III (Southern)

American Society for Metals
(To be appointed)

American Society for Quality Control
Lawrence M. Debing (Western New England)

American Society of Mechanical Engineers
Jules W. Lindau, III (Southern)

American Society of Safety Engineers
(To be appointed)

American Standards Association
William Lewi (New York) and Norman A. Skow (Philadelphia) Alternate

ASTM Cellular Materials Coordinating Committee
Frank W. Reinhart (Baltimore-Washington)

ASTM Committee D-20 on Plastics
Kenneth A. Kaufmann (Chicago) and John B. Howard (Newark)

ASTM Subcommittee XXI D-20 ISO Unit
John B. Howard (Newark)

Building Research Institute
Jerome L. Formo (Upper Midwest)

Forest Products Research Society
(To be appointed)

Institute of the Aeronautical Sciences
(To be appointed)

Institute of Radio Engineers
Ralph L. Mondano (Eastern New England)

Instrument Society of America
Richard Wade (Akron)

International Standards Organization
Norman A. Skow (Philadelphia)

Manufacturing Chemists' Association
George W. Flanagan (Baltimore-Washington)

National Conference on the Application of Electrical Insulation
Max M. Lee (Northern Indiana)

National Electrical Manufacturers Association
T. Walter Noble (Milwaukee)

National Society of Corrosion Engineers
Raymond S. Perkins (Non-Section)

Society of Automotive Engineers
Richard C. Oglesby (Detroit)

Society of Motion Picture & TV Engineers
Herbert Meyer (Southern California)

Society of Photographic Scientists & Engineers
Herbert Meyer (Southern California)

Society of the Plastics Industry, Inc.
Russell B. Akin (Philadelphia)

Technical Association of the Pulp & Paper Industry
Gordon K. Storin (Buffalo)

Meetings

ADMINISTRATOR
F. L. Fine (Chicago)

MEETINGS COMMITTEE
Guy A. Martinelli (New York)

STANDING SUB-COMMITTEES
ANTEC, C. H. Whitlock (Detroit)
NATEC, RETEC, S. H. Greenwood (Philadelphia)

1961 ANNUAL TECHNICAL CONFERENCE
Gordon M. Kline (Baltimore-Washington)

Publications

ADMINISTRATOR
M. F. Malone (Quebec)

PUBLICATIONS COMMITTEE
A. Sacher (New York)

TECHNICAL VOLUMES COMMITTEE
Hiram McCann (New York)

EDITORIAL ADVISORY BOARD
Frank W. Reinhart (Baltimore-Washington)

Administrative

ADMINISTRATOR
J. B. Schmitt (Pittsburgh)

FINANCE
R. K. Gossett (Chicago)

CONSTITUTION AND BY-LAWS
John M. Berutich (Kentuckiana)

ELECTION INSPECTORS
E. L. Larkin (New York)

NOMINATING
Frederick C. Sutro, Jr.

PUBLIC RELATIONS
E. Stollenwerck (Kansas City)

Sections & Membership

ADMINISTRATOR
J. R. Lampman (Central New York)

MEMBERSHIP
S. M. Crawford (Cleveland)

STUDENT MEMBERSHIP SUB-COMMITTEE
R. W. Ehlers (Eastern New England)

CREDENTIALS
Donald W. Biklen (Newark)

SECTIONS
G. P. Humphrey (New York)

SPEAKERS SUB-COMMITTEE
D. E. Eells (St. Louis)

NEW SECTIONS DEVELOPMENT
John T. Moore (Pioneer Valley)

Ad Hoc Committees

COUNCILMEN'S TRAVEL EXPENSE
R. A. Jenkins (North Texas)

FUTURE ORGANIZATION OF MANAGEMENT OF SOCIETY
R. Kenneth Gossett (Chicago)

EXECUTIVE OFFICE

Executive Secretary,
Thomas A. Bissell

Manager, Administrative Dept.,
Lewis A. Bernhard

Administrative Assistant,
Robert D. Forger

Publications & SPE Journal Editor,
Melvyn A. Kohudic

Advertising Manager, SPE Journal,
Leon R. Noe

65 Prospect St., Stamford, Conn.

SECTION NEWS

Detroit

Annual Christmas Meeting

C. E. BECK

The Detroit Rubber and Plastics Group, Inc., which is sponsored by the Division of Rubber Chemistry of the American Chemical Society, met for its annual Christmas meeting on December 11, 1959 in the Statler-Hilton Hotel. Six hundred and fifty members and guests enjoyed a program of entertainment.

Officers installed for 1960 were Chairman, Walton D. Wilson, R. T. Vanderbilt Company; Vice Chairman, S. Miller Sidwell, Chrysler Corporation; Secretary, Richard W. Malcomson, E. I. DuPont DeNemours and Company; and Treasurer, Phillip V. Millard, Automotive Rubber Company.

Other members of the Board of Directors are W. F. Miller, E. J. Kvet, Jr., H. W. Hoerauf, Counsellors; R. C. Waters, Program Chairman; P. Weiss, Assistant Program Chairman; E. Francis, Assistant Secretary; C. E. Beck, Publicity Chairman; T. W. Holloran, Historian; J. Masden, Membership Chairman; E. I. Bosworth, Assistant Membership Chairman; R. Snyder, Education Committee Chairman; F. Falvey, Assistant Treasurer; R. C. Chilton, Entertainment Chairman; C. H. Albers, Assistant Chairman, Education Committee; and J. McClellan, Program Committee member.

Ontario

134 People Attend Christmas Party

HAROLD A. SHURE

The Christmas Party of the Ontario Section was held on Tuesday December 15th, at the Town and Country in Toronto. One hundred and thirty-four people were there. The ladies were delighted with their gifts and the men approved of the "special" female Santa Claus. A door prize was promised and through a "fixed" draw the lucky winners were Section President John Glen and Mrs. Glen who received a miniature shanty door, complete with new moon and catalogue!

The committee who arranged the Party were under the chairmanship of Jim Wallace, and included Mr. and Mrs. Al Orr, Mr. and Mrs. Charlie Seay and Mr. and Mrs. Jim Wallace. The Sections heartiest thanks went to all who organized this really wonderful party.

The following officers have been elected for 1960. Harry Watson, editor, Canadian Plastics magazine, president; vice president is Harry Hutton, Toronto Plastics Limited; secretary is Charles Seay, Eastman Chemical Company, and treasurer is Hugh Cairns, Canadian Chemical Company, Limited. Don Halbert, F & H Plastics, elected director. Mac Lees, Canadian General Electric Company, Ltd., was appointed chairman of the RETEC on Automation to be held in Toronto in October.

Pioneer Valley

Ladies' Night

ROGER JOHNSTON

A grand night was had by all those in attendance at the Wachusetts Country Club on December 10, 1959. The occasion was Ladies' Night, when the ladies were treated to the Club's famous roast beef and dinner entertainment.

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Akron

M. Krajcik—New President

MERLE J. SANGER

The Akron Section reported a total membership of 156 as of December 10, 1959. This put Akron in third position in the membership drive. At a meeting of the officers and directors the following slate of new officers were chosen for 1960.

PRESIDENT –
Milan Krajcik
Rubbermaid Corp.
Wooster, Ohio

VICE-PRESIDENT –
Edward L. Hillier
Chamberlain Lab.
Stow, Ohio

SECRETARY –
Richard K. Senn
National Rubber Machinery Co.
Akron, Ohio

TREASURER –
Foster J. Young
Goodyear Tire & Rubber Co.
Akron, Ohio

The Akron Section heard a talk on "Design, Fabrication, and Erection of Large Radomes" by Mr. George Fretz of Goodyear Aircraft Corporation on January 25th. The meeting was held at the University Club, 105 Fir Hill, in Akron, Ohio. A movie and slides were presented to illustrate Mr. Fretz's talk.

Upper Midwest Section

Christmas Party

CHARLES M. SMITH

As far as the wives and girl friends of the Minneapolis Section members are concerned, the December meeting was a huge success. The Christmas Party was held in the "Party Den" of the President Cafe, Minneapolis, Minnesota. Social hour was at 7:00 P.M., Dinner at 8:00 P.M., Movie at 9:00 P. M. and Dancing at 10:00 P.M. The movie concerned operation "Man-High" by Monsanto Chemical Company.

Bridgeport, Conn.

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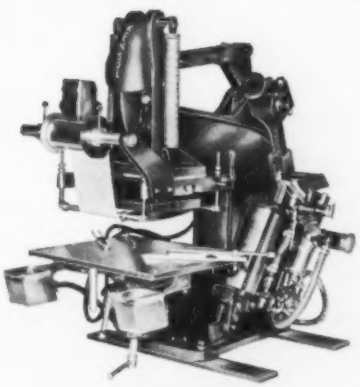

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dicted by Mr. W. A. Kelley, Monsanto Chemical Company, at the monthly meeting of the Connecticut Chapter, held at the Hotel Barnum, Bridgeport, Connecticut, Friday evening, December 11, 1959.

Mr. Kelley described in detail the history, major applications, materials used, principles involved in the forming operations and equipment which has been developed to perform this operation on a commercial basis.

Movies showing plastic sheets being formed were narrated by Mr. E. B. Stratton, Auto-Vac Company of Bridgeport.

In the business session of the meeting new officers for 1960 were elected:

President –
Harlan Fisher
Watertown Manufacturing Co.
Watertown, Connecticut

Vice President –
Ralph Esposito
W. S. Rockwell Company
Bridgeport, Connecticut

Treasurer –
Peter P. Paulishak
General Electric Company
Bridgeport, Connecticut

Secretary –
Henry Mastriano
The Patent Button Company
Waterbury, Connecticut

National Director –
William Coughlin
Naugatuck Chemical Company
Naugatuck, Connecticut

As special guests for the evening, the Chapter was honored by the presence of the SPE Executive Secretary, Mr. T. A. Bissell and the Secretary's Administrative Assistant, Mr. R. D. Forger.

Baltimore-Washington

Tour of Research Laboratory of the W. R. Grace Co.

S. P. PROSEN

The Baltimore-Washington Section of the Society of Plastics Engineers held their January meeting at the Washington Research Center of the W. R. Grace Company, Clarksville, Maryland. The Society was given a tour of the Research Laboratory at 7:30 PM. The Research Laboratory is doing work in the fields of high polymers, high purity silicones, agricultural chemistry and other fields. At 8:30 the group heard Mr. Harold Purinton, of Stein Brothers and Boyce, speak on the Plastics Industry from the Stock Broker's Point of View.

The meeting took place on Tuesday, January 19, 1960.

NEW BOOKS

THE LOCATION OF THE SYNTHETIC-FIBER INDUSTRY

Joseph Airov, Published jointly by The Technology Press and John Wiley & Sons, Inc., New York 1959 xii + 203 pp. $9.75

A qualified economist himself, Prof. Airov has written for other economists rather than for plastics engineers. Reading this book, the technical man may be startled to learn that celluloid was cellulose acetate (p. 17) or to find a Congressional hearing given as a reference for an explanation of fiber-forming properties (p.20). The study is restricted to five synthetic fibers: nylon 66, Orlon, Acrilan, Dynel, and Dacron. Polypropylene fibers are not mentioned anywhere although Teflon fibers are touched upon in three places. But even the technical man may not enjoy the research report-tpye of outline which the author follows since the net effect, in this instance, is one of abrupt transitions early in the book.

Under the sub-title of "A Case Study in Regional Analysis", this book appears to have two principal goals. The first is to show how theory may be applied in the new field of Regional Science. In this regard, the handling of data is most interesting although the use of economic data obtained from patents might be questioned. The second goal is to explore the possibility of locating a synthetic fiber plant in Puerto Rico on the basis that Puerto Rico is a low labor-cost area. This study, incidentally, was supported by the Social Science Research Center of the University of Puerto Rico. However, the author may have anticipated recent labor organizing activity in that area. In any event, he sidesteps any firm conclusions or separate predictions regarding a synthetic fiber industry on the island of Puerto Rico.

Because of limited scope of the material covered and the author's apparent goals, this book seems to hold little interest for plastics engineers except possibly in a few, very special instances.

Robert Doyle
Phillips Chemical Company

PHENOLIC RESINS

David F. Gould. Reinhold Publishing Co. 208 pages

This book will impress even the casual reader with the virtually endless versatility of phenolic resins. Considerable attention is focused to the many fields of application served by phenolic chemistry, and renewed interest will awaken in these fascinating plastics among those who have had previous acquaintances with them.

Of significant merit are the complete references ending each chapter. The reader thus can readily find additional information on subjects of particular interest.

Although the text is more of a survey, the technical graphs and tables spread throughout the 208 pages are a welcome addition. They help substantially to clarify important data.

The book begins with the present status of phenolics, and works its way through raw materials, production and major resin uses such as molding powder, adhesives, laminating, wood products, coatings and other applications. For the most part, reading is easy although certain passages become quite technical because of necessity.

PHENOLIC RESINS is recommended reading for the introductory student and for those wishing a basic survey of the fields influenced by phenolic products. Engineers, scientists and other technical people will find no direct application to engineering or design problems, but may discover the excellent references useful to pursue their interests in further detail. It belongs on the shelf of any individual concerned with phenolics or related thermosetting materials.

Alexander Jung
Rohm and Haas Co.

ORGANIC CHEMISTRY OF HIGH POLYMERS

Carl S. Marvel. John Wiley & Sons, Inc., New York. 82 pages, $4.50.

Professor Marvel has written this book in lecture style. The text is a simple introduction to polymer chemistry and it does present a clear conception of the fundamentals involved. Most of the types of organic polymers are discussed and the various methods and mechanisms of polymerization are explained. Graft polymers and block polymers are described. Polymer reactions are mentioned. In all cases, the discussions are brief, easily understood, and cover the more important principles. The author has presented a work which should be valuable as a textbook for elementary polymer chemistry.

William R. Lawton
Nashua Corp.

ABOUT MEMBERS

Milton T. Schimmel was elected president of Decorative Engineering and Supply Inc., Gardena, Calif. Since 1958, Mr. Schimmel has been a finishing consultant for the Logo Division of Bee Chemical Co.

Val Heisel, member of the St. Louis Section, presented a talk at the Society of Packaging and Handling Engineers. Title of his talk was "The Fastest Growing Field in Plastics—Blow Molding."

Joseph Eveland has been named plastics sales manager for the European area by Dow Chemical International Ltd. S.A.

Philip J. Meeks was appointed to succeed Eveland as head of the international section of Dow's Plastics Technical Service. Meeks holds a B.S. degree in management engineering from Rensselaer Polytechnic Institute.

Thomas P. Murphy has been appointed development manager for Fiberfil, Inc., Warsaw, Ind. Mr. Murphy served as independent consultant for members of the plastics industry. Earlier, he was employed in sales, market development, and engineering for Spencer Chemical Co., Kordite, and Du Pont.

Paul Stahlberg, Springfield, Mass., BS chemistry, University of Massachusetts (1945) and MS chemistry, Columbia University (1948), has been appointed product sales manager, Lustrex molding materials, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as technical service manager, polyethylene, there.

C. K. Rosenbaum has been named alternate councilor to the ACS's Division of Polymer Chemistry. Dr. Rosenbaum is with Du Pont at the Experimental Station, Wilmington, Del.

Richard E. Gromacki has been transferred to the new products sales department, M.A. Division, Wyandotte Chemicals Corp., from the company's research division.

Charles E. Rank, Chicago Section, was elected Executive Vice President of the Harry Davies Molding Co., Chicago. Mr. Rank will also continue to act as General Manager of the corporation.

Frank H. North passed away, Saturday, November 21, 1959. Mr. North joined the Harchem Division of Wallace & Tierman Incorporated in 1946. In recent years his activities were confined to New York State, New Jersey and Philadelphia.

John A. Parsons has been elected President of the American Plastics Corporation, a subsidiary of Heyden Newport Chemical Corp. Parsons formerly was executive vice president and has also served as director and vice president in charge of production.

William E. Wiese, Springfield, Mass., BS chemical engineering, University of Wisconsin (1939) and MBA business administration, American International College (1958), has been appointed assistant product sales manager, Saflex, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as coordinator of customer visits there.

Richard M. Thews, Springfield, Mass., BS chemistry, Rutgers University (1942), has been appointed manager of sales training for Monsanto Chemical Company's Plastics Division at Springfield, after serving as assistant product sales manager of Lustrex molding materials there.

Walter Agurkis, Charlotte, N. C., BS chemical engineering, Northeastern University (1938), has been appointed a sales representative at Monsanto Chemical Company's Plastics Division sales office at St. Louis, after serving as assistant district manager at the division's Charlotte, N. C., office, which has been discontinued.

Prescott Coan, Springfield, Mass., BS chemistry, Amherst College (1940) and MBA business administration, American International College (1959), has been appointed technical service representative, Lustrex, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as a member of the division's industrial and building applications group there.

Thomas A. DeMarco, Springfield, Mass., BS engineering, Massachusetts Institute of Technology (1930), has been appointed technical service manager, record materials, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as manager of the division's industrial and building applications group there.

Eli A. Haddad, Springfield, Mass., BS chemistry, Holy Cross College (1940), has been appointed manager of technical service, plastic products, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as assistant director of technical service there.

Charles E. Hamlin, Springfield, Mass., BS engineering, U. S. Naval Academy (1943) and MS agricultural engineering, Iowa State College (1948), has been appointed technical service manager, vinyl resins and compounds, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as a phonograph record materials specialist there.

Kenneth L. MacIsaac, Springfield, Mass., BS chemistry, Queens College (1941), has been appointed assistant product sales manager, vinyl resins and compounds, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as assistant district sales manager of the division's New England office there.

Robert A. McCarthy, Springfield, Mass., MS chemical engineering, Washington University (1947), has been appointed technical service manager, polyethylene, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as a member of the Lustrex technical service group there.

Robert R. Moyer, Springfield, Mass., BA business administration, University of Chicago (1939), has been appointed manager of technical service, resin products, for Monsanto Chemical Company's Plastics Division at Springfield, after serving as assistant director of technical service there.

Ralph W. Rohlfing, Springfield, Mass., BS chemistry, University of Illinois (1940), has been appointed district sales manager, resin products, at Monsanto Chemical Company's Plastics Division New York office, after serving as assistant product manager, Opalon, at Springfield.

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TECHNICAL MEETINGS CALENDAR

17th ANTEC

Annual Technical Conference—January 24-27, 1961, Shoreham Hotel, Washington, D.C. Sponsored by the Baltimore-Washington Section. General Chairman: Dr. Gordon Kline, National Bureau of Standards, Washington, D. C.

1960 RETECS

Offers of papers in the technical area of each Regional Technical Conference are solicited by each sponsoring Section. Please submit offers and abstracts to RETEC Chairman or Section President indicated below for each RETEC:

April 20—Plastics in the Petroleum and Chemical Industries, North Texas Section, Worth Hotel, Fort Worth, Texas. Chairman, Raymond S. Perkins, c/o Southwestern Pipe Co., P. O. Box 117, Mineral Wells, Texas.

September 8 and 9—Vinyl Plastics and Plastics in the Shoe Industry, Eastern New England Section, Statler-Hilton Hotel, Boston, Mass. Section President: Gim P. Fong, 9 Maple St., Auburndale, Mass.

September 22—Plastics in Business Machines, Binghamton Section, Sheraton Inn, Binghamton, N. Y. Chairman; John E. Gwyn, 179 Leroy Street, Binghamton, N. Y.

October 19—Tooling for the Plastics Industry, New York Section, Hotel Commodore, New York City. Section President: Edward Larkin, c/o Monsanto Chemical Co., 445 Park Avenue, New York City.

November 7—Automation in Injection and Compression Molding, Ontario Section, Toronto, Ontario. Chairman: J. M. Lees, c/o Canadian General Electric Co., 755 Division St., North Cobourg, Ontario, Canada.

November—Plastics in Corrosion, Golden Gate Section. Chairman: J. W. Richardson, c/o Rohm & Haas Co., 600 California St., San Francisco 8, Calif.

November 18—Blow Molding, Newark Section, Newark, N. J. Chairman: Robert Hoehn, Mack Molding Co., Ryerson Ave., Wayne, N. J.

EUROPLASTICA 60.

In June 18th-26th, 1960, an Exhibition entirely devoted to the Plastics Industry will be held in the world famous Floralies Palace in Ghent. This Trade Fair, which will be of a broadly based European character, will be organized in close collaboration with the Office Belge des Matieres Plastiques. For further information apply to:

1) Europlastica Secretairate,
Palais des Floralies,
GHENT—Flanders

2) Office Belge des Matières Plastiques,
Galerie du Centre, Bloc 3,
Rue des Fripiers,
BRUSSELS.

INTERNATIONAL EXHIBITION

An International Plastic Exhibition will be held in Oslo, Norway in 1960. The exhibition opens on Thursday, May 19th and closes Sunday, May 29th.

Society Action—(Continued from page 222)

9. EXECUTIVE OFFICE
Thomas A. Bissell, Executive Secretary

(a) Prepare anticipated growth plan for next five years—to include personnel, office precedures, and space requirements. Submit completed plan and proposal to October 1960 Council for action.

(b) Establish closer and more effective communications between Executive Office and Sections.

. . . . . .

Although we are already assured of the cooperation of one of the finest groups of committee chairmen ever to be listed in the Roster of the Society, these achievements can only, and will only, be realized with the assistance of many working committeemen and the cooperation of each and every member of the Society.

This then is our sincere appeal to you, Mr. SPE member—please give your assistance when requested. Or better yet, please offer your assistance, your ideas and suggestions. Your reward, and ours will be in the knowledge that our efforts are effectively contributing toward a better Society and a better industry.

edited by **Thomas A. Bissell**
SPE Executive Secretary

EPOXIES USED IN AIR CAR

Ford Motor Company's Levacar Mach I, the first full-scale, wheelless vehicle utilizing air propulsion is given a trial run at the Rotunda, Dearborn, Mich., by Dr. Andrew A. Kucher, vice president—engineering and research. Dr. Kucher first proposed the "sliding on air" concept more than 30 years ago. Styling of the Levacar was done by Ford's styling office, directed by vice president George W. Walker (standing). The car shown here was built in 3 weeks and 4 days by Wettlaufer Engineering Corp., Detroit, from a clay model provided by Ford styling. Use of epoxy resin formulations speeded construction of the interior assembly and molding areas the length of the Levacar.

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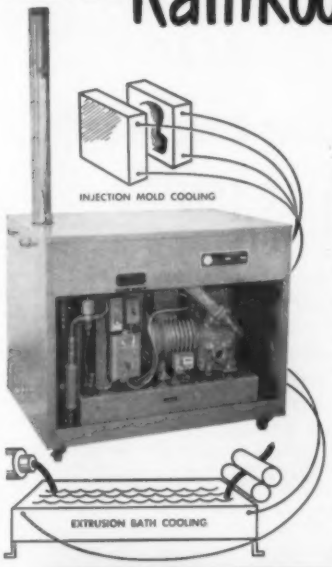

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MODEL	R-50	R-100	R-150
Watts	3100	4800	6875
Length	45	50	55
Width	29	30	34
Height	36	36	42
Weight #	650	700	1050
Temp. range °F.	40-50	40-50	40-50
#/hr. Injection @ 40°F.	75	125	190
#/hr. Injection @ 50°F.	95	155	230
#/hr. Extrusion Bath @ 40°F.	85	140	206
#/hr. Extrusion Bath @ 50°F.	105	170	253

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Employment & Service Guide

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Plant Superintendent leading West Coast reprocessing company wants man heavy production experience reprocessing thermoplastics, emphasis on Polyethylene, Polystyrene, Cellulosics and some Vinyl experience. Complete familiarity with banbury and extrusion operation. Approximately 40 employees, three shift operation. Reprocessing and coloring sub standard, scrap and first grade thermoplastics. Please send full information on experience, education, present salary and salary required. All information will be kept in strict confidence. Reply Box No. 960, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

DESIGN AND DEVELOPMENT ENGINEER

For creative position with National Company in suburban New York. M.E. preferred. Background in package machinery, plastics processing or automation helpful. Should be able to take project from drawing board to production. Opportunity for advancement to management position. Send resumes to Box 660, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

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HEAD

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Progressive Company expanding into plastic bottle business wants a metropolitan New York salesman. Experience in blow molding preferred. Salary open. Send resumes to Box *1060*, Society of Plastics Engineers Journal, 65 Prospect St., Stamford, Conn.

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Aggressive responsible engineer who can get things done quickly and accurately. Degree or equivalent, with machinery design experience and preferably some knowledge of plastics extrusion. To assist Chief Engineer in supervision of extruder design department.

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New Brunswick, N. J.

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Graduate Chemical Engineer. Wide experience in Plastics. Technical Sales Service and Market Research background both in the US and Europe. Knows French and German. Extensive European personal contacts. US citizen European background. US trained. Seeks position in Europe. Reply Box 860, SPE JOURNAL, 65 Prospect Street, Stamford, Connecticut.

PRODUCT DEVELOPMENT

20 Years experience in product development, process engineering, production management. Original thinking and extensive laboratory and plant background in following: cellulose acetate and wire compounding, polyethylene film extrusion, floor tile, polyester and acrylic casting, styrene polymerization.

Original work and patent applications in chalk boards, coated cement blocks, building veneers and panels, sandwich construction, plastic tabletops. Reply Box *1160*, SPE JOURNAL, 65 Prospect Street, Stamford, Connecticut.

MARKETING OR SALES

BS in Chemical Engineering. Five years experience in engineering laminated plastics. Twelve years sales and marketing in laminates and wide variety of electrical insulating materials with major manufacturer. All employment experiences with above average results. Desire relocation with position in marketing or sales in the New England area. Minimum salary $12,000. Reply Box *2060*, SPE JOURNAL, 65 Prospect St., Stamford, Connecticut.

PLANT MANAGER

Experienced in all phases of injection molding. Desire position with growing company. Have 20 years experience supervision plant set-up, mold and machine maintenance, directly responsible for hiring of personnel and setting up of systems and procedure. Reply Box *1260*, SPE JOURNAL, 65 Prospect Street, Stamford, Conn.

ENGINEER-MANAGER

Mechanical engineer, P.E. with over 15 years experience in chemicals, plastics and packaging. Supervisory background in project engineering, research and development. Heavy experience in polyethylene films development and manufacture. Additional work in plastic coatings, laminations and converting operations. Excellent knowledge of extrusion equipment and production methods. Seeks challenging position in product development, production or sales engineering. Reply Box *1360*, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

POSITIONS WANTED

PLASTICS ENGINEER

Twenty years experience in the plastics field, notably tooling, with additional work in injection molding, manufacturing engineering, processing, and development. Desire connection with a progressive company in the administration of tooling and development. Further details and resume will be forwarded upon request.

Reply Box *1460*, SPE JOURNAL, 65 Prospect St., Stamford, Conn.

PRODUCT DEVELOPMENT

Seven years experience developing plastics activities for large manufacturer of high speed electronic test equipment. Seven years experience in management of plastics fabrication business. Experienced in supervision of engineering and production groups. Resident of Pacific Northwest. Will relocate. 32 years old. Cooperative and creative. Resume sent on request. Box 560, SPE JOURNAL, 65 Prospect Street, Stamford, Connecticut.

TEN YEARS EXPERIENCE

Ten years practical experience in both compression and injection molding. Excellent molding knowledge of thermoplastics and thermoset compounds. Duties have included maintenance, trouble shooting, quality control and technical service. Non-production position preferred. Married and willing to relocate, preferably in the Southwest or Western part of States.

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SPE pins of new design and material can now be obtained from the SPE National Office. The pin is die-molded of zinc in the design shown in the illustration. The SPE red is in baked enamel finish and the letters and margin are provided by the gold of the die casting showing through.

In approving the new material and design, the Membership Committee emphasized that both the plastic pin, distributed previously, and the new die-molded zinc pins are official SPE pins. The zinc pin does *not* supersede the plastic pin.

The new pins are mailed gratis to all new members admitted to the Society since the supply of plastic pins became exhausted.

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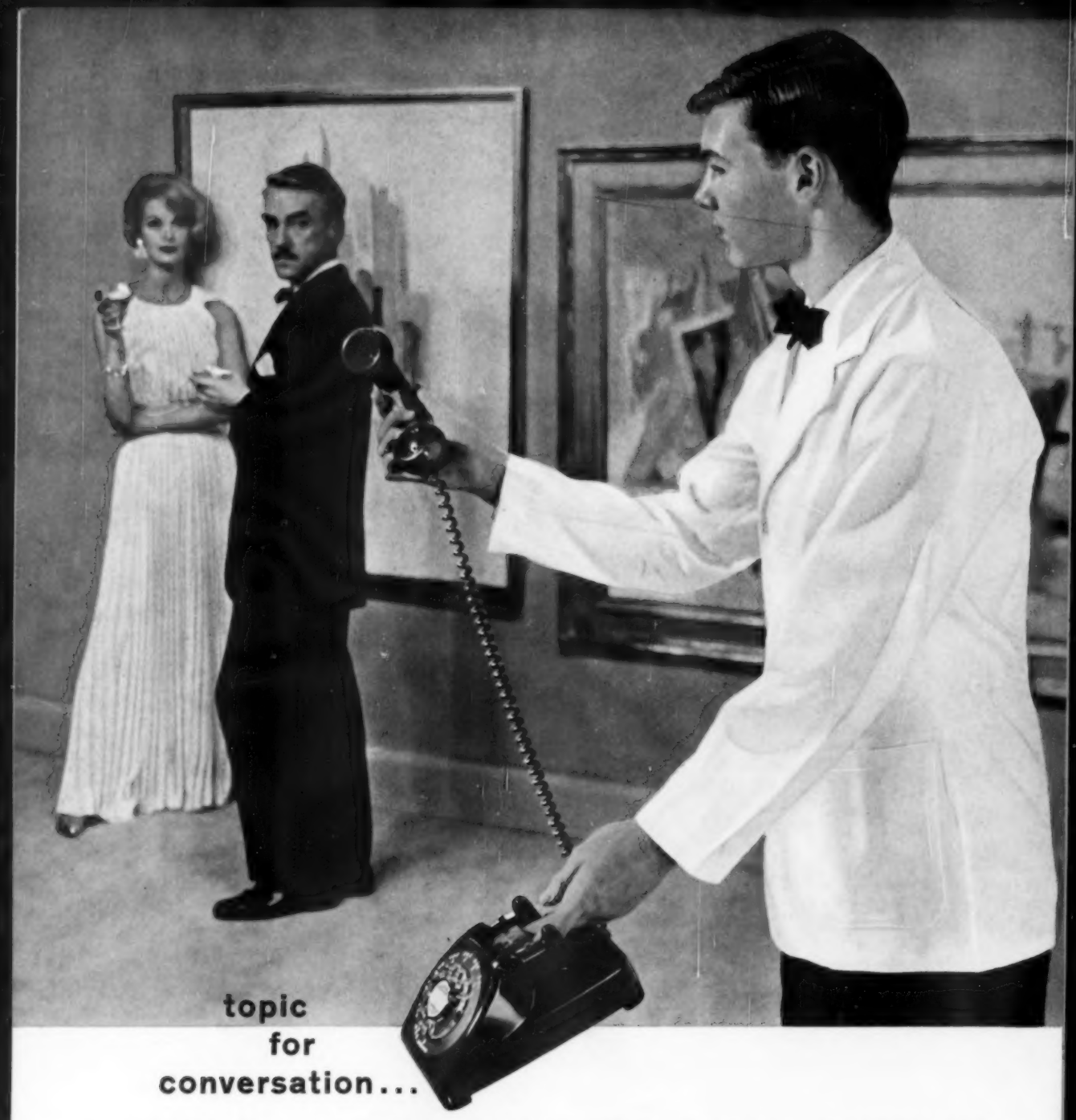

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